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ANGIONEPHROGRAPHIC EFFECT IN RENAL DAMAGE

An experimental study in dogs

by

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The normal nephrographic effect in renal angiography (the angionephrographic effect) was investigated experimentally by the writers in 1959. The study indicated that the initial filling of the vessels during the injection is of little importance in the angionephrogram, the phenomenon mainly depending upon the contrast medium accumulated in the tubular cells and ducts, but also upon the presence of contrast medium in the veins due to back diffusion of the contrast medium from the tubular cells.

In a study of angionephrography EDSMAN (1957) pointed out that a local contraction of the vessels during the injection and demarcation of ischaemic portions peripherally in a normal kidney may occur at angiography. He regarded the changes as functional and not pathologic.

In experimental studies of canine kidneys, intentionally damaged at angiography, the angionephrographic effect may have a course and a type deviating from the normal. The present study is based upon selective renal angiographies with abnormal angionephrographic effect in 11 healthy dogs.

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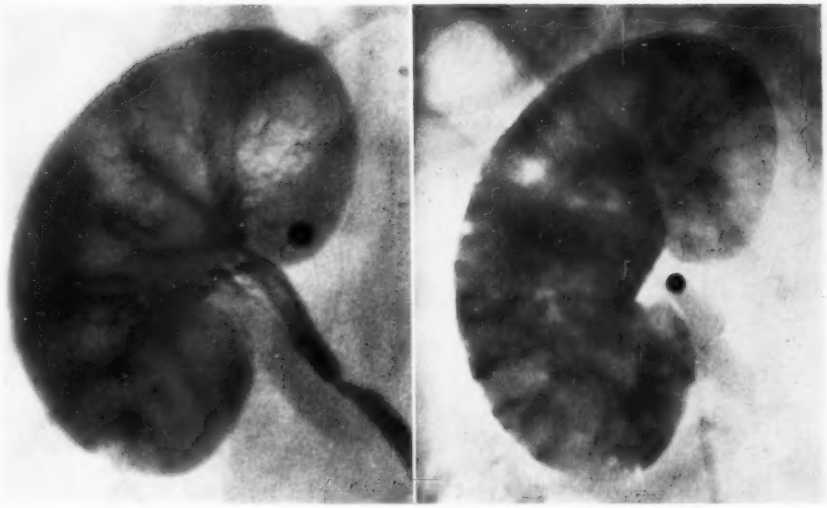
Before the angiography, Heller's test, the sediment and specific gravit of urine, and the non-protein nitrogen level and cellular picture of th blood from the dogs were normal. The dogs were kept under superfici general anaesthesia during the examination. After transfemoral catheter ization the contrast medium was injected into the right renal arter (Edholm & Seldinger 1956); the media used were triiodine compound (Miokon 50 %, Rheopak 40 %), and a diiodine compound (Umbrad 50 %). A test dose of 2 to 3 ml of the contrast medium was injecte for checking the position of the catheter during fluoroscopy. In nin dogs, 0.8 to 3.1 ml Miokon 50 % per kg of bodyweight were injected In the two remaining dogs, 0.5 ml Umbradil 50 % and 0.4 ml Rheopal 40 % per kg of bodyweight, respectively, were injected by means of a catheter sufficiently large to occlude the renal artery. The injection rat in all animals was 4 to 5 ml per second. Exposures were made by means of an automatic film changer with roll film (Elema) in seven of the dogs, in the rest 1 to 3 single films were taken. When the automatic film changer was used, the exposures were 2 per second for 8 seconds, 1 per second for 8 seconds and 1 every three seconds; this enabled the vascular passage to be timed.

Results

In the seven dogs examined with the film changer the filling of the vessels and the accumulation of the contrast medium in the kidney differed markedly from that in the normal angionephrographic effect.

In two of the dogs there was a contraction of the artery at the tip of the catheter throughout the injection; in one of them the contraction persisted when the artery remained filled after the end of the injection (Fig. 1 a). The arteries remained filled in a total of 5 dogs, for 4, 7, 35, 35 and 35 seconds, respectively. In one of them the artery emptied in a retrograde direction into the aorta, enabling identification of the other renal artery as well. The interlobar arteries were more clearly seen than in normal cases. In all the seven dogs the renal vein was contrast-filled at the usual time, with the injection rate used, that is 3.5 to 4.5 seconds after the start of the intraarterial injection. The duration of the venous filling varied; in four dogs it was between 25 and 47 seconds, and within normal limits, in the remaining three it exceeded 2, 4 and 5 minutes, respectively, and was longer than normal.

The accumulation of contrast medium in the cortex faded out in three dogs after 40, 43 and 72 seconds, respectively, which is normal, but persisted in four animals for more than 5, 6, 8 and 11 minutes, respectively. The accumulation in the medulla remained longer than normal.



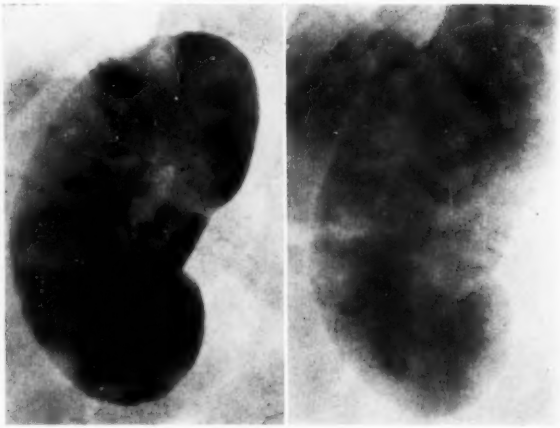
a b

Fig. 1. Selective renal angiography in dog: 1.9 ml Miokon 50 % per kg of bodyweight. a) 15 sec after injection. At tip of catheter contraction of renal artery was visible throughout (at least 40 sec). Accumulation of contrast medium, mainly cortically, and filling of vein. No excretion. b) 4 min after injection. Irregular and partly intense accumulation of contrast medium. Excretion has started.

in one dog for 1.5 minutes, in the remaining six for 6 to 12 minutes. The contrast medium either accumulated diffusely (Fig. 2) or was very irregularly distributed (Figs. 1, 3). Peripheric defects and irregular streaks were noted in the cortex and irregular dense patches in other parts of the kidney. In one dog an irregular accumulation of contrast medium appeared both after the small test dose (Fig. 4) and after the main dose. In five of the dogs the contrast medium did not flow to the collecting ducts and there was no clear demonstration of the papilla, pelvis, and ureter. The two remaining dogs showed filling of the collecting ducts and more distinct density of the papilla; in these two dogs the contrast medium also emptied into the pelvis and ureter, indicating excretion.

The four dogs which were not timed were examined with single films instead of roll films. In two of these dogs the contrast medium was injected by means of a catheter occluding the renal artery, and thus into renal tissue intentionally rendered ischaemic. One dog was exposed at the end of the injection, the remaining three also after 5, 8, 10, or 15 minutes. The findings agreed with those described above; in the latter three dogs the irregular density was still visible 10 to 15 minutes after

Fig. 2. Selective renal angiography in dog: 1.4 ml Miokon 50 % per kg of bodyweight. Exposure 5 min after injection. Marked accumulation of contrast medium and poor filling of the renal vein. Metal clips localize the pedicle.



a b

Fig. 3. Selective renal angiography in dog: 1.7 ml Miokon 50 % per kg bodyweight. a) 10 min after injection. Dense and irregular accumulation of contrast medium in entire lower half of kidney and irregular accumulation in the cortex of the upper half. b) 15 min after injection. Contrast medium remains in a restricted area in the lower part. No excretion.

the injection. Only in one of them did the papilla increase distinctly in density.

All kidneys that had shown an abnormal angionephrographic effect were found to have marked histologic changes as signs of severe renal damage. In three of them, which were studied by selective clearances before and after the injection of contrast medium, functional disturbances also developed after the injection. The correlation between the angionephrographic, functional and morphologic findings is discussed elsewhere (EDLING, HELANDER, PERSSON and ÅSHEIM 1959). In the kidneys into which no contrast medium was injected there were no disturbances of function, and/or no morphologic changes.

Discussion

An abnormal angionephrographic effect may appear after a small as well as after a large dose of contrast medium. In one case it was present even after the injection of the small test dose of 3 ml triiodine compound 50 %, and appeared again after a second dose of 12 ml, when the first effect had disappeared. In the two kidneys with intentionally provoked ischaemia the doses were also relatively small. With large doses of a

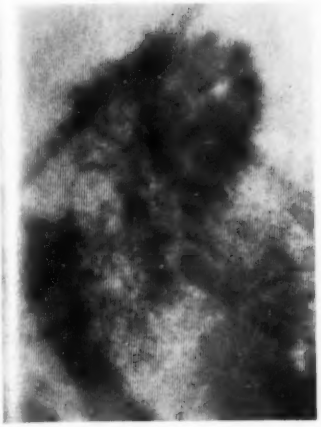


Fig. 4. Selective renal angiography in dog. Irregular accumulation of contrast medium after a test dose of 3 ml Miokon 50 %.

triiodine compound the abnormal angionephrographic effect might show different degrees of severity. Other series, however, indicate that the angionephrographic effect could be normal after injection both of large and of such small doses of contrast medium that caused damage to the kidney (EDLING, HELANDER, PERSSON and ÅSHEIM 1959). Thus, the abnormal angionephrographic appearances are not correlated to the doses of contrast medium injected. It therefore seems unreasonable to presume that they should depend upon the contrast medium as such, by causing, for example, oedema of the capillaries. It seems more probable that they depend upon a reflex influence of the contrast medium or upon the catheter, which might cause ischaemia anywhere in the renal tissue.

The retention of the contrast medium in the renal artery and vein, and their branches, a long time after the end of the injection suggests that the intrarenal circulation is impeded. The fact that the contrast medium accumulates irregularly in the cortex, and anywhere in the medulla for some minutes without passing to the papilla for emptying into the pelvis, indicates that it remains in the vessels and tissues instead of being excreted into the tubules. These findings suggest that the blood pressure in the glomeruli is too low for filtration, and that the blood flow is so reduced that the tubular cells are not able to function (EDLING, HELANDER and RENCK 1954); thus, for some minutes there might be no glomerular filtration or tubular excretion, and no back diffusion to the veins (EDLING and HELANDER 1959). It seems as if severe intrarenal vascular disturbances were the common cause of the findings. If the angionephrographic effect decreases without filling of the collecting ducts and the pelvis this is an indication of back diffusion from the tissues into the blood. Such a back diffusion has been suggested by the writers elsewhere, and is confirmed by the disappearance after hours of the nephrographic effect in ureteral obstruction at urography even though no excretion occurs.

The disturbance in the circulation and the impaired function of the excretory system indicates that the abnormal angionephrographic effect mainly depends upon retention of contrast medium in the vessels and tissues, unlike the normal angionephrographic effect, which in the main is due to accumulation of contrast medium in the excretory system.

SUMMARY

The authors have studied the angionephrographic effect in renal damage by selective renal angiography in a material of 11 dogs. They describe the deviations from the normal accumulation of the contrast medium. The findings indicate that the abnormal effect depends mainly upon retention of the contrast medium in the vessels and tissues of the kidney.

ZUSAMMENFASSUNG

Die Verfasser haben den angionephrographischen Effekt bei Nierenschäden mit Hilfe der selektiven renalen Angiographie an einem Material von 11 Hunden studiert. Sie beschreiben die Abweichungen von der normalen Kontrastaufladung. Die Befunde zeigen an, dass der abnormale Effekt im wesentlichen auf der Retention des Kontrastmittels in den Gefässen und Geweben der Niere beruht.

RÉSUMÉ

Les auteurs ont étudié par angiographie rénale sélective sur un matériel de 11 chiens l'effet angionéphrographique dans les lésions rénales. Ils décrivent les différences avec les images normales. Les résultats montrent que l'effet angionéphrographique anormal dépend surtout de la rétention du moyen de contraste dans les tissus et les vaisseaux du rein.

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ABSORPTION OF IOPANOIC ACID AND ITS SODIUM SALT

by

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The diagnostic reliability of oral cholecystography largely depends on the degree of absorption of the contrast medium employed. The introduction of the tri-iodide substances of 3-(3-amino-2,4,6-tri-iodophenyl) 2-ethyl propionic acid (*i. e.* iopanoic acid) type was an important advance, owing to their higher iodine content compared with the earlier di-iodide contrast media. The new substances are relatively insoluble, however, which results in two disadvantages: there is uncertainty in the assessment of the incompletely filled gall-bladder, since unsatisfactory absorption cannot be excluded, and large quantities of contrast medium remain in the intestine. This latter fact may in some cases confuse the appearances in cases of biliary calculus. If an attempt is made to counteract the low absorption by increasing the dosage, this is achieved at the cost of an increase in the residual contrast medium in the bowel and greater discomfort to the patient.

By replacing iopanoic acid (Telepaque, Bilijodon, etc.) by its sodium salt (Bilijodon-Natrium, Leo, Sweden) a water-soluble contrast medium is obtained. Iopanoic acid is indeed precipitated by the hydrochloric acid in the stomach but in an amorphous and not crystalline form, which gives a greater absorption area per unit weight.

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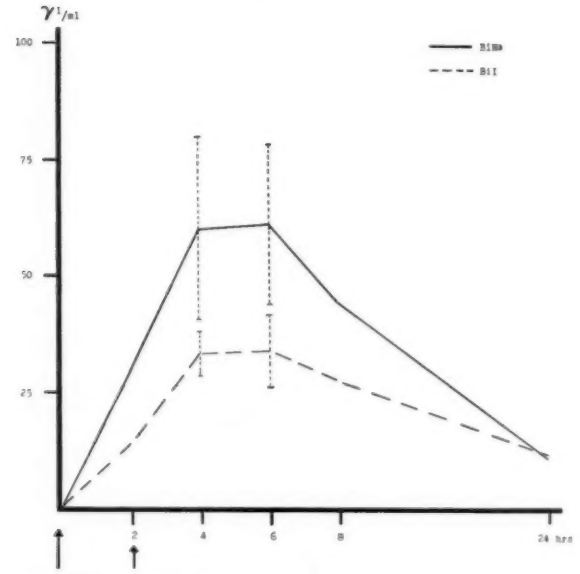

Diagram showing the difference in absorption between iopanoic acid (Bilijodon, BiI) and its sodium salt (Bilijodon-Natrium, BiNa). The curves represent the means and their 95 % confidential limits.

The rate and degree of absorption may be judged either by an estimation of the amount of substance remaining in the bowel or, more precisely and with more reliability, by determining the iodine content of the blood.

PETERHOFF (1956) has made a comparison of iopanoic acid and its sodium salt by recording the quantity of unabsorbed contrast medium in the intestine. On the administration of 4 tablets of the salt, unabsorbed contrast medium was present in 8.5 % of cases and, with a dose of 6 tablets, in 13 %. A dose of 6 tablets of iopanoic acid was associated with unabsorbed contrast medium in 43.5 % of cases. A similar investigation was made by the present authors (1957). A dose of 4 tablets of the sodium salt was associated with incomplete absorption in 38 % of cases, and with 8 tablets in 59 %, whereas the administration of 12 tablets of iopanoic acid produced unabsorbed contrast medium in the bowel of 87 % of cases.

Both these investigations indicated that the sodium salt is absorbed more completely. The numerical differences between the results may probably be explained by differing methods of preparation of the patient and the different dosage.

Material. The series consists of 26 patients referred to our department with suspected gall-bladder disease. Half of these were given 8 tablets of the sodium salt (in two doses at an interval of 2 hours), and half received a single dose of 12 tablets of iopanoic acid. The preparation for the roentgen examination was similar in all cases.

The first blood sample was taken immediately before the tablets were swallowed and further samples were obtained after 2, 4, 6, 8 and 24 hours. The roentgen examination was carried out after the 8-hour test. Several analyses were made on each blood sample (standard deviation ± 3 %). The analyses were performed in the analytic laboratory of AB Leo.

Results

The results of the analyses are shown in the diagram.

The upper curve represents the 13 patients given the sodium salt, and the lower curve the 13 who received iopanoic acid. The greatly superior absorption of the sodium salt is obvious. Although the dose of sodium salt administered contains 2.57 g of iodine, compared with 4 g of iodine in the dose of iopanoic acid, the blood-iodine curve reaches a much higher level in the former case. The velocity of absorption in the two groups seems, however, to be roughly similar and roentgen examination should therefore be carried out after the same interval with both substances. It is further evident from the curve that there is no difference between the two 24-hour figures, indicating that the elimination of iodine from the blood takes place at the same rate.

The distribution of functioning and non-functioning gall-bladders between the two groups was about equal. Assessment of the series with this in view produces the same result as when the series is considered as a whole.

SUMMARY

The absorption of iopanoic acid and its sodium salt has been compared by estimating the iodine content of the blood. The investigation confirms earlier findings based on assessment of the amount of unabsorbed contrast medium in the bowel. The sodium salt of iopanoic acid is much better absorbed than iopanoic acid, and is therefore more satisfactory in oral cholecystography.

ZUSAMMENFASSUNG

Die Absorption der Iopansäure und deren Natriumsalz ist durch Schätzung des Jodgehaltes des Blutes verglichen worden. Die Untersuchung bestätigt frühere Befunde, welche sich auf einer Schätzung des Gehaltes von nicht resorbiertem Kontrastmittel im Darm gründet. Das Natriumsalz der Iopansäure wird viel besser absorbiert als die Iopansäure; sie ist daher besser für die orale Cholecystographie geeignet.

RÉSUMÉ

L'absorption de l'acide iopanoïque et de son sel sodique ont été comparées par estimation de la teneur en iode du sang. Ce travail confirme les résultats antérieurs basés sur la détermination de la quantité de moyen de contraste non absorbé dans l'intestin. Le sel sodique de l'acide iopanoïque est beaucoup mieux absorbé que l'acide iopanoïque, et est par conséquent plus satisfaisant pour la cholécystographie par voie orale.

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ABSORPTION OF UROKON FROM THE G. I. TRACT

by

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The aqueous organic iodide contrast media have found recent application to G. I. tract radiography, largely as a result of human and animal experimentation which has found them to be poorly absorbed from the gastrointestinal tract. Radiographic evidence of marked absorption, however, has been reported by CANADA (1955) in four of thirteen cases examined with Urokon and in one of twenty-seven cases studied by GIPSON (1957) with Gastrografin. We have noted radiographic evidence of absorption in 5 of a total of 19 cases examined with a contrast medium consisting of 60 ml Gastrografin 76 % in aqueous solution with 20 ml of 1 % dioctyl sodium sulfosuccinate, an anionic wetting agent marketed as a stool softener in the treatment of constipation, and employed by us to facilitate contact between contrast medium and bowel mucosa.

A review of these 5 cases (Table 1) suggests that a direct communication between the G. I. tract and the vascular system as a result of a pathologic bowel may have been the responsible factor for the radiographic findings noted in Cases 1, 2, 3. No explanation is known for the findings in Cases 4 and 5.

Accordingly a study was instituted to evaluate the effect of wetting agents, intestinal motility, and variation in concentration and pH of the

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Table 1

Case No.	Diagnosis	Bleeding from G. I. tract	Type of examination	Evidence of absorption of contrast medium	Allergic reaction to absorbed medium
1	Duodenal ulcer	+	Stomach and small bowel	In urinary bladder at 60 minutes	None
2	Diverticulosis of sigmoid	+	Stomach and small bowel	In urinary bladder at 4 hours	None
3	Malignant invasion of ileum by recurrent rectal carcinoma	+	Stomach and small bowel	In renal pelvis at 2 hours (Fig. 1)	None
4	No organic pathology	—	Colon with air-contrast enema	In renal pelvis 10 minutes after start of examination (Fig. 2)	Nausea urticaria
5	Metastatic carcinoma of cervical lymph nodes. Primary not determined.	—	Stomach and small bowel	In renal pelvis at 90 minutes	None

Table 2

Preparation administered	Number of cases	24 hour urinary excretion %	24 hour urine volume ml	24 hour thyroid uptake %
50 μC radioactive Urokon	4	20.94	1,816	2.86
3.5 g Carrier Urokon (5 ml 70 % Urokon added to 50 μC radioactive Urokon)	4	8.12	1,270	3.34
Hypodermic injection of banthine (50 mg) prior to administration of 3.5 g Carrier Urokon and 50 μC radioactive Urokon	3	8.96	1,352	3.13
20 ml 1 % carboxymethylcellulose added to 50 μC radioactive Urokon	4	19.42	1,720	3.22
20 ml 1 % dioctyl sodium-sulfosuccinate added to 50 μC radioactive Urokon	4	19.18	1,595	2.73
3 ml 10 % HCl added to 50 μC radioactive Urokon	3	19.19	1,680	3.42
4.0 sodium bicarbonate added to 50 μC radioactive Urokon	3	11.65	1,415	2.60

contrast medium on its absorption from the gut. Twenty-five individuals with no known abnormality of the G. I. tract, urinary tract or thyroid and without history of iodide sensitivity or recent iodide intake, ingested 50 μC of radioactive Urokon with the addition of those substances whose effect on absorption we had planned to evaluate. Medications and enema

Fig. 1. Oral pyelogram at 2 hours in a case of malignant infiltration of ileum from recurrent rectal carcinoma.

were withheld for 24 hours before and after the start of the study; subjects fasted for 9 hours before and 3 hours after the oral ingestion of Urokon. The radioactivity of the 24 hour urine sample and of the thyroid gland at 24 hours was determined in terms of percentage of Urokon administered (Table 2).

The findings indicate that approximately one-fifth of the Urokon, ingested at tracer dose concentration, is excreted in the urine during the first 24 hours; 3 % is concentrated in the thyroid, probably representing iodide ions split off from the benzoic acid nucleus of Urokon. No significant effect on absorption of the tracer dose is obtained by the addition of an anionic wetting agent (dioctyl sodium sulfosuccinate), a non-ionic wetting agent (carboxymethylcellulose), or by acidification of the Urokon with 3 ml 10 % hydrochloric acid. A 40 % decrease in absorption is effected by alkalinization with 4 g sodium bicarbonate. An additional benefit of alkalinization is suggested by our observation that Urokon, Hypaque and Renografin are precipitated by strong mineral acids, suggesting the possibility of *in vivo* precipitation in the stomach. Substance is given to this observation by EPSTEIN (1957) who reports suggestive radiographic evidence of precipitation of Hypaque in one of his cases. A twofold purpose of decreased absorption and prevention of precipitation may be served by the addition of an alkalinizing agent to these media.

When the concentration of administered Urokon is increased by adding 3.5 g Carrier Urokon (5 ml of 70 %) to the 50 μC of radioactive Urokon (for all practical purposes the amount of Urokon administered is that

of the Carrier Urokon) the 24 hour urine sample contains 6.3 to 11 % (mean of 8 %) of the administered dose. Thus when 3.5 g Urokon are ingested, 0.221 to 0.385 g (mean of 0.280 g) of Urokon are excreted in the urine within 24 hours. A comparison with the data as determined after the oral administration of radioactive Urokon alone indicates that at the higher dose there is a decrease in both the percentage of orally administered Urokon excreted in the 24 hour urine sample, and in the volume of urine excreted in 24 hours. The decreased volume results from the increased osmolarity of the Urokon at higher concentration causing a diffusion of fluid into the bowel lumen.

Fig. 2. Air-contrast enema. Film taken 10 min after commencement of examination. Rapid excretion of absorbed contrast medium.

A further extension of these findings is obtained by comparison with a report of DAVIS et coll. (1956) that following the oral ingestion of 35 g Urokon 0.78 to 2.8 % of the ingested amount is excreted in the 24 hour urine sample. Thus following the oral ingestion of 35 g Urokon, 0.273 to 0.980 g of the Urokon administered is excreted at 24 hours. A tenfold increase in the amount of Urokon ingested (from 3.5 g to 35 g) results in an almost proportionate decrease in the percentage of Urokon absorbed, as evidenced by the minimal increase in the total amount of Urokon excreted in the urine at the higher dose level. The hypothesis that the cathartic-like action of Urokon at higher concentration is the responsible factor in limiting absorption was tested by the hypodermic injection of 50 mg banthine 15 minutes prior to the oral ingestion of 3.5 g Carrier Urokon added to 50 μC of radioactive Urokon. No appreciable effect on absorption was noted.

Although Urokon, as well as the other aqueous organic iodides, is absorbed rapidly from the peritoneal cavity and fistulous tract, it would appear that the physical and chemical make-up of the contrast medium is the limiting factor in its absorption from the gut. It is possible that in the diseased bowel, the mucosal barrier is disrupted and absorption enhanced. The effect of organic pathologic changes in the bowel in the absorption of these media is currently under study and will be reported in the near future.

Acknowledgements

The author wishes to acknowledge his indebtedness to Dr. Charles Ross, Chief of Thoracic Surgery and Mr. Robert Case, Chief Pharmacist, for their cooperation and assistance in the performance of this study.

SUMMARY

At roentgen examinations of the G. I. tract, with Gastrografin in solution with an anionic wetting agent, marked absorption of the contrast medium was observed in 5 out of 17 cases. In three of these patients the bowel was pathologic. In a series of 25 cases, using orally ingested radioactive Urokon at tracer dose concentration, approximately one fifth of the Urokon was excreted in the urine in 24 hours. Modification of the contrast medium by use of an anionic wetting agent, a non-ionic wetting agent, and by acidification has no appreciable effect on absorption. Alkalinization, however, reduces absorption and is also recommended to prevent precipitation of the contrast medium in the stomach. It is concluded that absorption from the normal gut is limited.

ZUSAMMENFASSUNG

Bei 5 von 17 Patienten, deren Magen-Darmkanal mit einem Kontrastmittel, bestehend aus Gastrografin in Lösung mit einem anionischen Mittel röntgenuntersucht worden war, erhielt man Anzeichen einer markierten Absorption des Kontrastmittels. Von 3 dieser Patienten wusste man, dass sie darmkrank waren. Eine Studium an 25 Personen unter Benutzung von per os verabreichtem radioaktiven Urokon zeigte, dass ungefähr 1/5 des in Spurendosiskonzentration benutzten Urokon innerhalb von 24 Stunden im Urin ausgeschieden wurde. Die Modifikation des Kontrastmittels durch Verwendung eines anionischen Mittels, und eines gleichartig wirkenden jedoch nicht dissoziierten Mittels, und durch Azidifikation, hatten keinen merkbaren Effekt auf die Absorption. Eine Alkalinisierung reduziert jedoch die Absorption und wird auch zur Vorbeugung einer Ausfällung des Kontrastmittels im Magen empfohlen. Es wird konkludiert, dass eine Absorption vom normalen Darm nur in begrenztem Ausmasse geschieht.

RÉSUMÉ

Sur un total de 17 malades dont l'estomac et l'intestin ont été examinés avec un moyen de contraste fait de Gastrografin en solution avec un agent mouillant anionique, l'auteur a obtenu dans 5 cas la preuve d'une absorption marquée du moyen de contraste. Trois de ces malades avaient une affection intestinale connue. L'étude de 25 sujets par ingestion d'Urokon radioactif montre qu'environ un cinquième de l'Urokon, à concentration de dose traceuse, est excrété dans l'urine en 24 heures. La modification du moyen de contraste par addition d'un agent mouillant anionique, d'un agent mouillant non-ionique ou d'un acidifiant n'a pas d'effet appréciable sur l'absorption. L'alcalinisation, par contre, réduit l'absorption et est aussi recommandée pour empêcher la précipitation du moyen de contraste dans l'estomac. L'auteur conclut que l'absorption par l'intestin normal est limitée.

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DIAGNOSTIC VALUE OF PELVIC ARTERIOGRAPHY IN TUBAL PREGNANCY

by

Hüsnü Özaras

Several papers on the diagnostic value of pelvic arteriography in tubal pregnancy have been published from this Department and the Department of Womens' Diseases of Karolinska Sjukhuset (BORELL, FERNSTRÖM, LINDBLOM and WESTMAN 1952 and 1953; BORELL and FERNSTRÖM 1953; BORELL, FERNSTRÖM, and WESTMAN 1955; FERNSTRÖM 1955; BORELL 1955).

These investigations have shown that the arteriographic appearances enable the diagnosis of tubal pregnancy to be made if the placental sinuses communicate with the adnexal branches of the uterine artery, and also if the placental sinuses contain circulating blood. The arteriographic diagnosis of the condition is not possible in cases of complete tubal abortion or rupture of the tube. The differential diagnosis between tubal pregnancy and intra-uterine pregnancy may be difficult because the corpus luteum of pregnancy, owing to its vascularity and site, may be confused with small opaque placental sinuses lying outside the uterus.

As the number of cases of ectopic pregnancy examined by pelvic arteriography has steadily increased since the above papers were published a review of the arteriographic appearances in such cases was considered to be of interest.

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Material

The present series comprised 57 pregnant women; 37 of them had a tubal, and the remainder an intra-uterine pregnancy. In the cases of tubal pregnancy the tube affected was either resected or completely extirpated and the operation specimen was microscopically examined. The duration of the pregnancy was calculated from the first day of the last menstrual period and varied between 35 and 210 days. In 17 of these 37 cases a biologic pregnancy test was carried out and was negative in 5.

As already mentioned, the arteriographic differential diagnosis between ectopic and early intra-uterine pregnancy may be difficult. For this reason the investigation was extended to include 20 cases of intra-uterine pregnancy and the appearances in these cases were compared with those in ectopic pregnancy. The duration of the intra-uterine pregnancy in these cases, calculated from the first day of the last menstrual period, varied between 40 and 80 days. Some of the patients had been referred for pelvic arteriography on account of suspected ectopic pregnancy; others attended for legal abortion, and pelvic arteriography was carried out to investigate whether the procedure induced labour. Pelvic arteriography showed the ectopic pregnancies to be intra-uterine and did not induce labour.

Three to four films were generally taken in each case. The total roentgen dose received by the foetal gonads and maternal ovaries was measured and calculated and was found to vary between 0.3 and 0.6 r. (For further details of the roentgenologic technique see FERNSTRÖM 1955.)

Arteriographic findings

Tubal pregnancy

The width of the uterine artery and of its adnexal branches. There was no appreciable difference between the two uterine arteries in respect to their width; nor did the course of the main trunk of the uterine artery on the side of the pregnant tube deviate appreciably from that of the contralateral. The number of small uterine blood vessels varied greatly in the individual cases but did not differ appreciably from that found in normal non-pregnant women.

In 26 of the 37 cases in this group, the uterine artery on the side of the affected tube was seen to give off one or more adnexal branches; their calibre was invariably found to be 1 mm or more. Adnexal branches of the contralateral uterine artery were identified in 14 of these 26 cases.

Fig. 1. Left tubal pregnancy of 45 days duration. *Top view*, taken immediately after completion of the injection of the contrast medium: g — uterine artery along lateral margin of uterus, p — left adnexal branch. *Lower view*, taken 2 sec later: in the centre, a large number of tortuous intramural blood vessels at the site of the uterus, p — right adnexal branch, t — opacified placental sinuses outside the uterus.

only in 6 was their calibre 1 mm or more. In 20 of the 26 cases in which adnexal branches of the uterine artery on the side of the affected tube were visible, they were seen to divide into several branches; in 11 of these they were found to be arched. On the other side the adnexal branches were observed to ramify in rare exceptions only: in none of these cases were they found to be arched.

Placental sinuses. Placental sinuses were contrast-filled in 28 cases. In 26 they were seen to lie outside the uterus; in the remaining 2 cases it was not possible to say with certainty whether they lay within or

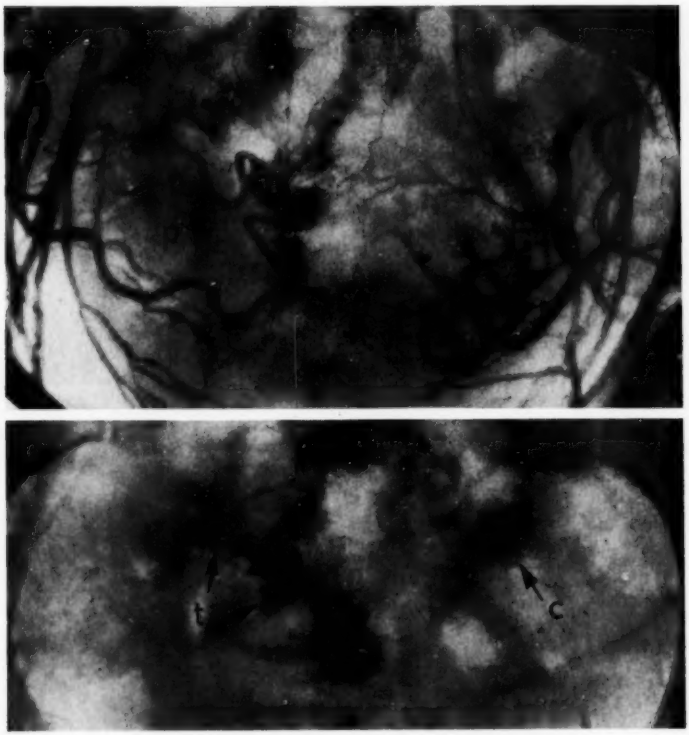

Fig. 2. Right tubal pregnancy of 60 days duration. *Top view*, taken immediately after completion of the injection of contrast medium: g — uterine artery along lateral margin of uterus, p — right adnexal branch. *Lower view*, taken 4 sec later: t — filled placental sinuses outside uterus, c — filled corpus luteum of pregnancy.

outside the uterus. In one of these latter cases there was interstitial tubal pregnancy and in the other the site of attachment of the placenta was the middle third of the tube. As the tube was fixed by adhesions to the posterior wall of the uterus, the placenta was projected so that it was shown to lie within the uterus.

The area in which placental sinuses were visible, measured from 5 × 8 mm to 50 × 100 mm. The placental sinuses were visible as mottled opacities of more or less irregular outline, the variation in the degree of density being due to variations in the depth of the placental sinuses (Figs. 1 and 2). In 11 cases draining veins were seen to arise from the placenta. In 3 of them the veins filled early in the arterial phase which suggested the presence of arteriovenous fistulae; in the remainder they filled late or after the arterial phase.

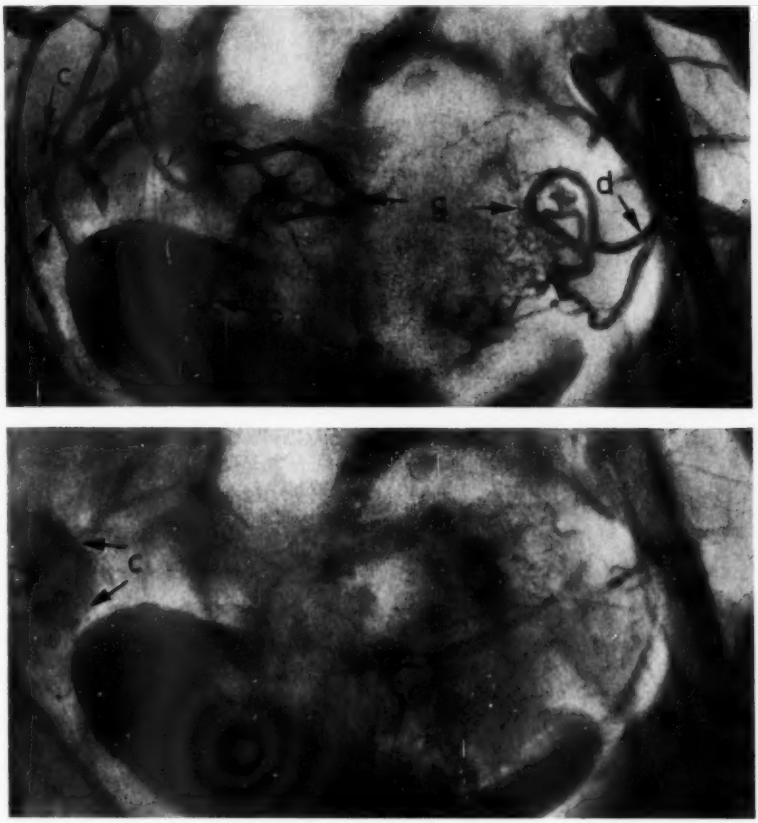

Fig. 3. Normal intrauterine pregnancy of 48 days duration. *Top view*, taken immediately after completion of the injection of contrast medium: d — uterine artery in parametrium, g — uterine artery along lateral margin of the uterus, p — adnexal branch on right side, c — corpus luteum of pregnancy beginning to fill. *Lower view*, taken 2 sec later: c — corpus luteum of pregnancy. No placental sinuses at the site of uterus.

Corpus luteum of pregnancy. In 3 of the 37 cases of tubal pregnancy a corpus luteum of pregnancy was identified on the side of the non-affected tube; it was found to be round or oval in shape and showed even distribution of the contrast medium; it measured from 10 × 10 mm to 10 × 20 mm (Fig. 2).

In 2 of the 37 cases of tubal pregnancy the blood supply of the latter was derived from one ovarian artery.

Intra-uterine pregnancy

The width of the uterine artery and its adnexal branches. The width of the uterine artery did not differ appreciably from that of the uterine artery in the normal non-pregnant uterus. In the majority of cases in which the pregnancy was of three lunar months' duration, the fundal branches were seen to be non-tortuous.

Placental sinuses. In the cases in which the duration of the pregnancy was 60 days or more small placental sinuses were visible in the fundus uteri; they were seen to be more evenly filled than the placental sinuses in tubal pregnancy. In no case were draining veins visible.

Corpus luteum of pregnancy. In 4 cases in this group in which the duration of pregnancy was between 50 and 70 days, a corpus luteum of pregnancy was seen. Its arteriographic appearance was identical with that of the corpus luteum of pregnancy observed in tubal pregnancy (Figs. 3 and 4). Its size varied between 15 × 20 mm and 20 × 25 mm. In one of these cases draining veins arising from the corpus luteum of pregnancy, filled after the arterial phase.

Discussion

It was found in this investigation that the adnexal branch of the uterine artery on the side of the affected tube generally showed the following arteriographic characteristics: its calibre was wide, it divided into several branches and some of these branches were arched. However, these arteriographic features are not diagnostic of ectopic pregnancy because similar appearances are also encountered in the presence of salpingitis or ovarian tumour (Borell and Fernström 1953, and Fernström 1955).

The demonstration of placental sinuses outside the uterus is proof-positive of ectopic pregnancy. The differential diagnosis from intra-uterine pregnancy may be difficult because the corpus luteum of pregnancy may occasionally be visible outside the uterus and may then be confused with ectopic pregnancy. However, the placenta in ectopic pregnancy has an irregular outline and fills unevenly (Figs. 1 and 2), whereas the corpus luteum of pregnancy is round or oval in shape, and generally has a regular outline: an additional characteristic is that it fills evenly (Figs. 2, 3 and 4). Familiarity with these arteriographic appearances will aid in correctly differentiating between the two conditions.

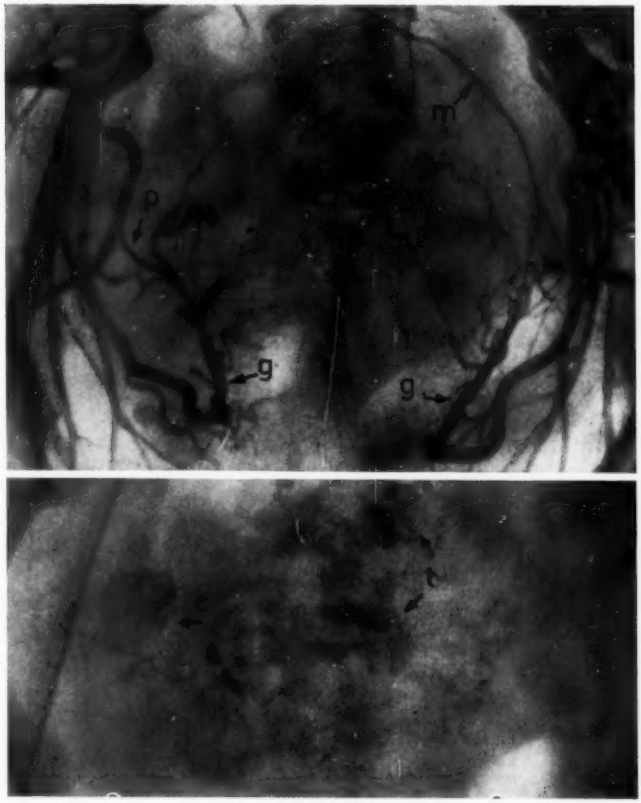

Fig. 4. Normal intrauterine pregnancy of 70 days duration. *Top view*, taken immediately after completion of the injection of contrast medium: g — uterine artery along lateral margin of uterus, m — non-tortuous fundal branch, p — right adnexal branch. *Lower view*, taken 2 sec later: t — filled placental sinus within fundus, c — filled corpus luteum of pregnancy.

In 26 of the 37 cases of tubal pregnancy in this series the correct diagnosis was made by demonstrating placental sinuses outside the uterus. In another 2 cases, in which placental sinuses filled, it could not be said with certainty whether they lay within or outside the uterus. No reliable diagnostic information was therefore obtained from the appearances. In both cases the blood supply of the placenta was derived from one uterine artery only. As this is rarely encountered in intrauterine pregnancy (FERNSTRÖM 1955) ectopic pregnancy was strongly suggested.

In the remaining 9 cases the arteriographic diagnosis of ectopic pregnancy was not possible because the placental sinuses did not fill; these were cases of complete tubal abortion or rupture of the tube. In such cases there is of course no communication between the tubal blood vessels and the placental sinuses and therefore pelvic arteriography does not enable the diagnosis of the condition to be made.

With the exception of the cases just described, tubal pregnancy can be diagnosed by pelvic arteriography. Occasionally the clinical diagnosis presents difficulty, particularly in the cases where a biologic pregnancy test is negative. The present investigation has shown that the correct diagnosis may be made from the arteriographic findings even in these cases.

In some cases pelvic arteriography resulted in filling of the ovarian artery. In 2 of them the blood supply of the tubal pregnancy was derived from this artery which enabled the correct diagnosis to be made; it is, however, only rarely that the blood supply of the tubal pregnancy appears to be derived from the ovarian artery. If filling of this artery is not obtained in such cases aortography has been found to be of diagnostic value.

There does not appear to be any relationship between the duration of the ectopic pregnancy and the possibility of diagnosing the condition arteriographically. The shortest duration in the cases of this series in which pelvic arteriography enabled the correct diagnosis to be made was 35 days. In the first lunar month an ectopic pregnancy seldom produces symptoms; if it does they are so slight that the patient does not seek medical advice. In the second lunar month they may prompt the patient to consult her doctor but at that stage the placental sinuses are sufficiently large to be seen.

The corpus luteum of pregnancy displays maximum endocrine activity during the first two lunar months of pregnancy. In the third lunar month it decreases in size and its hormonal secretion diminishes. One reason why contrast-filling of the corpus luteum was obtained in only 7 of the 57 cases investigated is probably that such arteriographic demonstration is possible only at the time of maximum secretory activity; one may reasonably assume that it is then particularly vascular. This assumption is supported by the fact that the duration of the pregnancy was 50 to 70 days in the cases in which the corpus luteum was demonstrated.

SUMMARY

The arteriographic diagnosis of ectopic pregnancy is made by demonstrating placental sinuses outside the uterus. Of 37 cases of tubal pregnancy verified by operation the diagnosis was made from the arteriographic appearances in 26.

ZUSAMMENFASSUNG

Die arteriographische Diagnose der Extrauteringravidität wird durch die Darstellung der Plazentarsinus ausserhalb des Uterus demonstriert. Von 37 Fällen mit Tubargravidität, die operativ bestätigt worden sind, ist die Diagnose in 26 Fällen auf Grund des arteriographischen Aussehens gestellt worden.

RÉSUMÉ

Le diagnostic artériographique de grossesse ectopique est fait par la mise en évidence de sinus placentaires en dehors de l'utérus. Sur 37 cas de grossesse tubaire vérifiée opératoirement, le diagnostic a été fait dans 26 cas sur les images artériographiques.

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BRONCHIAL ADENOMA

by

O. Ch. Pock-Steen

A bronchial adenoma is a relatively uncommon benign tumour of the lung encountered chiefly in fairly young subjects. It is, however, of no slight interest because its symptoms and signs resemble in several respects those of bronchogenic carcinoma.

A bronchial adenoma arises in the epithelium of the mucous and serous glands of the bronchi; in most cases the larger bronchial branches are involved, less often the smaller, more peripheral branches. Since the primary growth is into the bronchial lumen, a central tumour will be entirely or partially within the lumen of the larger bronchi and therefore not visible in a conventional chest film; it may, however, manifest itself by occlusion of the bronchial branch concerned, leading to atelectasis of a major or minor segment of the lung. On the other hand, a peripheral tumour will produce a roundish, homogeneous density and will more often be silent as it occludes only a small bronchial branch. The resulting small area of atelectasis is rarely observed and the growth causes few or no symptoms and in most cases is not detected until a routine investigation is performed.

Untreated, the condition after many years' duration often terminates in death from pulmonary complications or amyloidosis (4, 5). This applies particularly to central adenomas. The prognosis following surgical treatment is favourable.

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Present series

Nineteen patients have been treated for bronchial adenoma in the course of the past 15 years in our hospital. Five were men and fourteen women. Most age groups were represented, the youngest patient being 17 and the oldest 69 years. In all cases the diagnosis of bronchial adenoma was confirmed by microscopic examination. Diagram 1 gives the age distribution.

Symptoms and signs. Out of the 19 patients, two had no symptoms, the tumour being a chance finding in the course of a routine investigation. Most of the remaining 17 patients had attacks of fever, recurrent pneumonia, productive cough, and fatigue. Coughing up of blood was reported by half the patients; chest pain and difficulty with breathing were less common. The frequency of the various symptoms and signs is set out in Diagram 2.

Roentgen findings. In addition to ordinary chest films in two planes bronchography was performed in 5 cases, tomography in another 5, and bronchography as well as tomography in 4 additional cases. A few of these examinations had been performed at other hospitals before the patients were transferred to us.

In four instances the tumour had a peripheral site, whereas the remaining 15 were juxta-hilar and situated in the large bronchi. The most common site was the right upper lobe (6 cases). One tumour was at the carina. Of the 15 cases with central tumours 12 had massive atelectasis. In an additional case atelectasis was present only in the form of vague and transitory densities. Operation revealed a small tumour in the left lower lobe bronchus, which had evidently not caused total occlusion of the lumen. In two instances the old films were not available. In the four cases of peripheral tumour (Fig. 1) there was no atelectasis.

Among other roentgen findings it is worth mentioning bronchiectasis which was present in three cases. Two patients had unmistakable abscess cavities in the affected lung and one had a spontaneous pneumothorax.

In cases of central tumours most interest attaches to the tomographic and bronchographic findings. Tomography, performed in 7 cases of central tumours, disclosed a distinct, roundish, sharply defined lesion in the bronchus in 4 (cf. Fig. 2). In an additional case there was a more atypical occlusion of the bronchus. Bronchography, carried out in 8 cases of central tumours, also revealed a roundish, sharply defined filling defect (Fig. 3) in 4 and more atypical occlusion of the bronchus in 2 cases.

Tomography and bronchography thus revealed in more than half the cases a roundish lesion in a bronchial branch, one of which was sharply

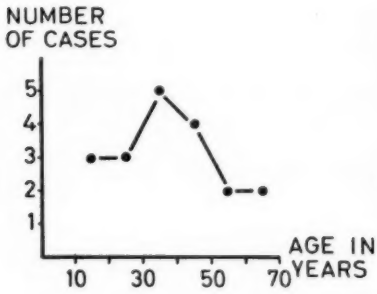

Diagram 1. Age distribution in the case material.

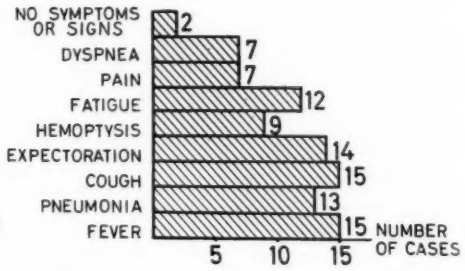

Diagram 2. Symptoms and signs in 19 patients with bronchial adenoma.

defined and consequently of a benign nature. The appearance of the lesion is characteristic; it is not pathognomonic of bronchial adenoma, however, as it may be present in cases of leiomyoma and other benign tumours arising in the bronchial wall.

Treatment. Most cases were treated by lobectomy or pneumonectomy. In three cases only excision of the tumour was performed (in one of them through the bronchoscope), and in one case electrocautery was successfully employed. The operative mortality was nil, and postoperative complications were rare. One patient developed a pneumothorax, one subcutaneous emphysema, and one empyema.

Discussion

Gross pathology. According to most pathologists, the bronchial adenoma arises in the serous and mucous glands of the respiratory tract (1, 2, 4). It presents itself as a roundish, greyish-red tumour, bleeding readily upon touch (3, 7).

Its most common localization is near the hilum, so that occlusion of the larger bronchi is a prominent feature. The growths usually range in size from a hazelnut to a walnut, but extremely large dimensions may be encountered, especially in the peripheral variety (5). Out of the present series of 19 tumours four were peripheral.

Microscopy. The tumour consists of strands and clusters of cells, usually in an alveolar pattern. The cells are frequently large and pale, and their nuclei are poor in chromatin (the carcinoid type (3, 10)); in

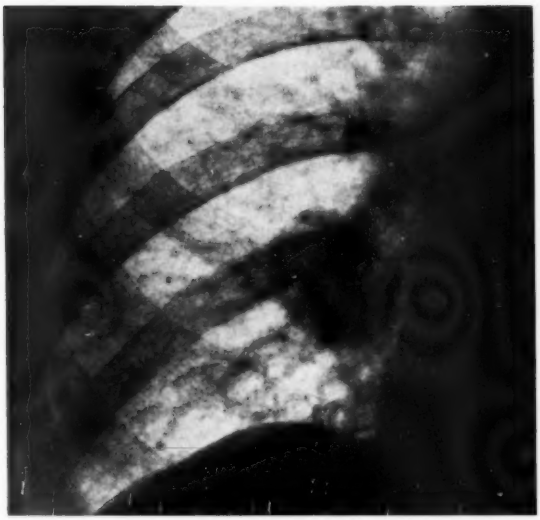

Fig. 1. Peripheral asymptomatic bronchial adenoma in a woman, aged 69.

other cases the nuclei are dark and the cytoplasm sparse (the cylindroma type). CARLENS, WIKLUND & BERGSTRAND (3) have mentioned a third type in which the regular pattern is absent and the cells vary within wide limits as regards size and chromatin content of the nuclei. Since the cytoplasm of these cells is stainable by mucicarmine in the same way as mucous cells, they suggested calling this type mucus-producing adenomas. Transitional varieties may be encountered. These authors found the cylindroma type only in central cases, and they consider this form to be most liable to undergo malignant transformation. In the present series, the only case with such change was of the cylindroma type but, unlike the authors mentioned, we ourselves found also the cylindroma type among peripheral adenomas (2 cases).

Bronchial adenomas show a tendency to invasive growth, and this characteristic has given rise to doubts regarding their benign nature (4, 8). Invasion was observed in nine cases of the present series.

Incidence. Bronchial adenoma makes up 10 per cent of all bronchogenic tumours (1). Although it is a fairly rare tumour, it is the most common among the benign growths of the respiratory tract (60 % or over), (8, 10). While carcinoma of the lung is generally encountered in

Fig. 2. Woman, aged 38, with a 10-year history of bronchial occlusion. Atelectasis of lower lobe. Typical rounded tumour pole in the tomogram. Operation revealed an adenoma, the size of a hazelnut, at the site of the bifurcation of the main bronchus.

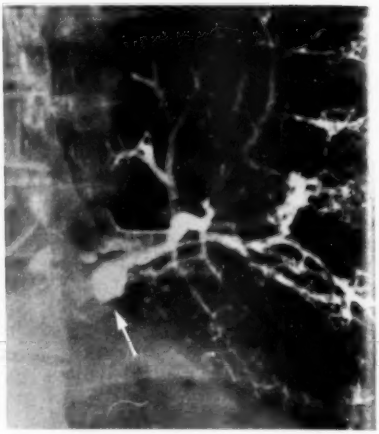

Fig. 3. Bronchography of left lung revealed a rounded defect in lower lobe bronchus of a 17-year-old girl with a 6-months history. Operation revealed an adenoma, the size of a hazelnut, at the site.

the 4th and 5th decades of life, bronchial adenoma is not infrequently seen in young subjects; more than half the patients of the present series were under 40 years of age. Most authors have reported a female preponderance (3, 4, 6, 9), and this was confirmed in the present study.

Malignancy. Bronchial adenoma shows some tendency to malignant transformation. Several cases have been reported in the literature (11). PERÄSALO (11) found one case of malignant transformation among four tumours; this tumour was of 15 years' standing. RUBIN & NEUHOF (12) have reported an average period of 12 to 15 years before the regional lymph nodes exhibit metastases; in their series the frequency of malignancy was 10 %. CARLENS, WIKLUND & BERGSTRAND (3) found 4 cases of malignant transformation among 70 of bronchial adenoma. In other words, it seems beyond doubt that bronchial adenoma must always be considered a potentially malignant tumour, and this view is shared by most authors (2, 4, 7, 10, 11). Considering, however, the long histories in numerous cases, the tendency to malignancy does not appear to be particularly marked. The only case of the present series in which the operation was not radical exhibited malignancy 12 years after the bronchial adenoma had been diagnosed.

Differential diagnosis

Peripheral bronchial adenoma may be confused with neurinomas, chondromas, hamartomas, leiomyomas, solitary metastases, cysts, tuberculomas, diaphragmatic hernias, and arteriovenous aneurysms.

Central, juxta-hilar adenomas usually manifest themselves only by bronchial occlusion, and consequently have to be differentiated from any lesion that may occlude the bronchi; in this connection, bronchogenic carcinoma is of the most importance. Chondromas and leiomyomas may lie in the same situation and foreign bodies in a bronchus may give rise to a similar appearance. Blood clots in the branch of a bronchus may at times simulate a bronchogenic tumour.

Conclusions

A bronchial adenoma may in rare cases be present as a silent, peripheral tumour and be revealed during a routine roentgen examination of the chest. In most cases, however, it arises in the larger bronchial branches near the hilum, and may thus produce bronchial occlusion and atelectasis of a large segment of the lung, giving rise to a productive cough and recurrent attacks of pneumonia.

Bronchography and tomography are of great diagnostic value and should be carried out in any case of recurrent pneumonia or atelectasis in young as well as in older subjects. If a bronchogenic tumour is present, these procedures may disclose a roundish, well-defined lesion projecting into the bronchial lumen; in a patient with a long history, such an appearance supports the diagnosis of a benign tumour. The simultaneous presence of haemoptysis indicates a bronchial adenoma, which is a tumour which readily bleeds; other benign bronchogenic tumours seldom give rise to haemoptysis.

Although the tendency to malignancy does not appear to be particularly marked, bronchial adenoma must be considered a potentially malignant tumour which invariably calls for radical surgery.

SUMMARY

The pathology, roentgen appearances, and treatment of bronchial adenoma, based upon a series of 19 operated cases, are described. The growth is an uncommon one but must be considered in the differential diagnosis of tumours of the lung, particularly in young subjects.

ZUSAMMENFASSUNG

Die pathologische Anatomie, das röntgenologische Bild sowie die Behandlung des Bronchialadenomes wird auf Grund der Erfahrungen in 19 operierten Fällen beschrieben. Die Geschwulst ist ungewöhnlich; sie muss jedoch bei der Differentialdiagnostik der Lungentumoren, insbesondere bei jungen Individen, beachtet werden.

RÉSUMÉ

Les auteurs décrivent l'anatomie pathologique, les aspects radiologiques et le traitement de l'adénome bronchique, d'après une série de 19 cas opérés. Cette tumeur est peu fréquente, mais on doit y penser dans le diagnostic différentiel des tumeurs du poumon, en particulier chez les jeunes.

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DISSECTING ANEURYSM OF THE THORACIC AORTA

by

Folke Knutsson

The underlying cause of a dissecting aneurysm is the occurrence of a small tear between the intima and adjacent part of the media through which the aortic blood is pumped at high pressure into the vessel wall. Two separate forms of dissecting aneurysms are described in the literature, these differing in situation and extent, as well as in the age at which they occur.

The classical form is due to degeneration of the smooth musculature and elastic tissue. This condition is called medio-necrosis aortae idiopathica and its etiology is unknown. The ascending and descending parts of the aorta in the region of the lig. arteriosum are primarily affected; this type of degeneration does not occur in the abdominal aorta. The blood which penetrates the vessel wall may dissect its way along the vessel for varying lengths and may partially or completely encircle the entire cross-section of the aorta; in this way a 'double-barrelled' aortic lumen may be formed. There has been speculation as to whether the intima lesion is the primary cause of the dissection or the result of a secondary break-through to the lumen of the aorta. This form of dissecting aneurysm occurs in middle-aged as well as in younger subjects. The risk of perforation into the periarterial space is considerable and most commonly occurs in the pericardium at the commencement of the descending aorta.

The arteriosclerotic form of dissecting aneurysm is caused by arteriosclerotic ulceration of the intima through which the blood passes into the degenerated wall of the aorta. The resulting aneurysm is limited in

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extent and no lengthy dissection occurs; the aneurysm may rupture into the periarterial space. This arteriosclerotic form usually occurs in the abdominal aorta and is encountered in elderly subjects, generally more than 60 years of age.

The acute onset of the condition is generally dramatic, with severe constrictive pain in the back, thorax, or abdomen, depending on the situation of the aneurysm; the patient is usually greatly distressed and anxious. The clinical picture varies, again with the localization of the aneurysm and the extent to which the different branches of the aorta are affected. The condition may also, however, develop gradually without marked symptoms; the immediate interpretation of the clinical picture is then of course difficult.

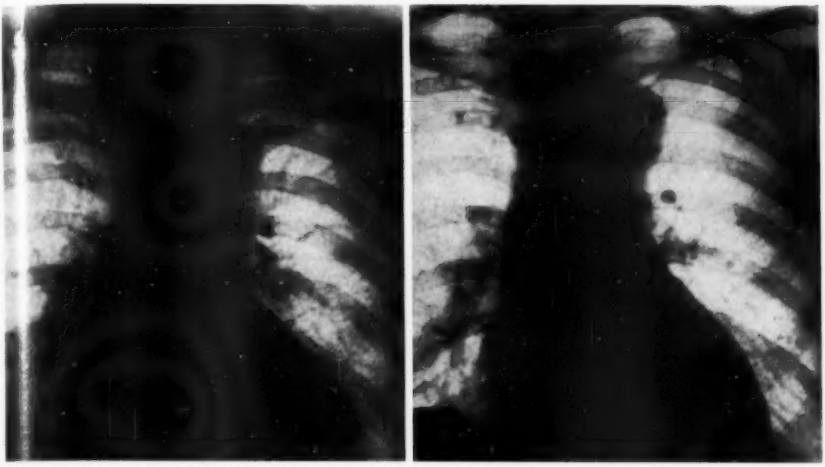
In view of the increasing tendency towards operative intervention, the diagnosis of dissecting aneurysm is becoming of increasing importance. Roentgen examination of the thorax may in some cases lead to the diagnosis which is based on the finding of a widened aorta in some particular region. Comparison of the films with those obtained at a previous examination, if possible, will help in a decision as to the nature of the widening. If the interval between the examinations is not too long the appearance of a widening may be diagnosed as being caused by a dissecting aneurysm since a true aneurysm takes considerable time to form. The contour of the aorta is often uneven within the area of the dissection and the degree of density is less than in the remainder of the cross-section of the aorta (HOLZMANN). The thickness of the wall may be determined more exactly when calcium deposits occur in the intima (LODWICK).

Aortography has recently been employed for the diagnosis of this condition; the aneurysm becomes filled with contrast medium (DE BAKEY et coll., WARREN et coll.).

Case reports

Case 1. Woman, aged 43 years, with hypertonia and cardiac enlargement, suddenly developed severe 'drawing pain' in the back while cycling and had difficulty in breathing.

Roentgen examination on her immediate admission to hospital, on 18 July 1954, (Fig. 1 a) showed cardiac enlargement, with some widening of the aorta in the region of the arcus. Three days later: presence of small bilateral pleural exudates which disappeared after two weeks. The severe pain in the back and epigastrium continued during the first three weeks of her stay in hospital after which it diminished and disappeared. Five weeks after her admission to hospital, a further increase in the width of the aorta (Fig 1 b) in the region of the arcus was observed, the change apparently being due to a dissecting aneurysm. The patient had initial fever and an increased sedimentation rate, but on leaving hospital, on 14 September, she had no abnormal signs or symptoms.



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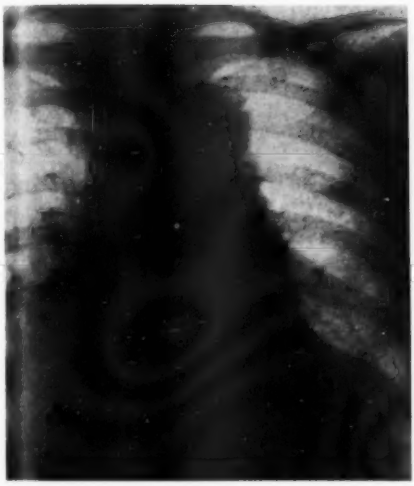


c

Fig. 1. Case 1.

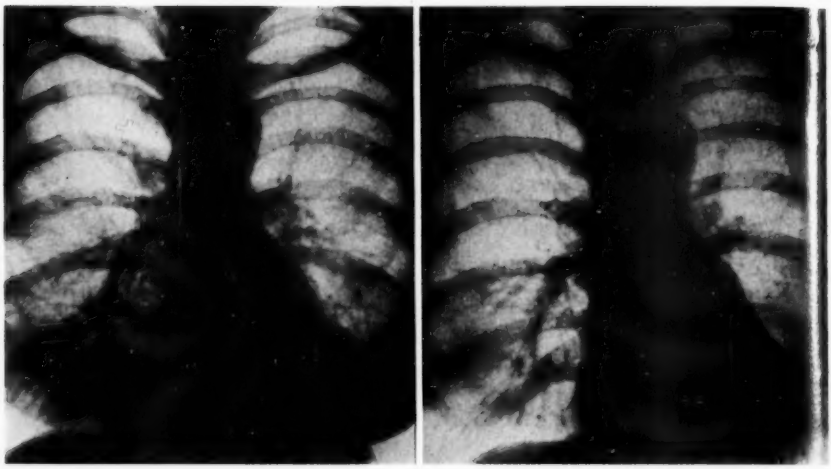
a) Film obtained at onset of symptoms showing moderate widening of the aortic arch possibly due to hypertension.

b) Five weeks later the widening has increased as a result of a dissecting aneurysm.

c) Four days after (b). Marked widening of the descending aorta now apparent and due to a further dissecting aneurysm.

The patient then felt generally well until 4 November 1954 when she again developed pain in the back and was admitted to hospital from 5 to 11 November.

Roentgen examination (Fig. 1 c) showed the width of the aorta in the arcus region to be unchanged but a diffuse enlargement with an ill-defined lateral contour of the descending part of the aorta had appeared. This indicated the occurrence of a second dissecting aneurysm.



a b

Fig. 2. Case 2. a) Aorta of normal width. b) Film obtained 2 months later at acute onset of symptoms. Diffuse widening of the aortic arch due to a dissecting aneurysm.

The patient's condition was satisfactory for three years when she was brought to hospital with a cerebral hemorrhage and died the same day.

Autopsy. General atheromatosis of the aorta. A brownish-red, speckled, encapsulated mass, the size of a walnut and necrotic in appearance, was present at the level of the lig. arteriosum. It appeared to be situated between the layers of the aortic wall, and a communication slightly larger than a little finger connected the mass with the aorta. A similar mass, nearly as large as a mandarin was found at the level of Th2. Other mandarin-sized masses were present in the aortic wall immediately above the renal arteries, respectively at the level of and somewhat above the inferior mesenteric artery. In the latter situation the aorta wall was necrotic. In each pleural cavity 50 ml of yellow fluid were found. Microscopy revealed marked degenerative changes in the media of the type generally seen in aneurysm of the aorta; fairly prominent arteriosclerotic changes were present.

Case 2. A woman, aged 28 years, with Marfan's syndrome (ectopia lentis + arachnodactyli), became suddenly ill with severe pain in the back, initially radiating out between the shoulder blades and later extending to the lumbar region. She was admitted to hospital immediately, and found to be distressed and restless.

Roentgen examinations of the abdomen, urinary tract and of the chest were considered normal. Her condition rapidly deteriorated and she suddenly died two days later as she sat up in bed.

Autopsy. On the right side of the aorta and inside the pericardium a rupture of 0.5 cm in length was found, together with a dissecting aneurysm of the wall. This latter lay on the dorsal aspect of the aorta from the level of the aortic valves to the aortic arch and downwards to the point of division of the descending aorta. The splitting of the wall involved slightly more than the dorsal half of the circumference of the aorta; the outer wall of the aneurysm was found to have perforated into the pericardium through a 3 cm

long rupture and the pericardium was filled with large blood coagula. Both pleural cavities contained smaller amounts of clear, yellowish fluid.

In this case, an examination of the chest had been performed 2 months prior to the admission to hospital. On a comparison of the film obtained at the acute onset (Fig. 2 b) with the one obtained at the earlier roentgen examination (Fig. 2 a) it was found that the latter showed a somewhat wider aorta in the region of the arcus. There is no doubt that the widening of the aortic arch observed at the roentgen examination was caused by the dissecting aneurysm which was revealed at the autopsy three days later.

Conclusions

A dissecting aneurysm of the thoracic aorta causes a local widening of the aorta. If films from a previous roentgen examination, in comparison with films obtained later, show that the widening of the thoracic aorta has arisen during a relatively short period this should permit of a diagnosis. The interval between the examinations is the deciding factor for distinguishing between a dissecting and a true aneurysm.

SUMMARY

The causes and clinical course of a dissecting aneurysm of the thoracic aorta are described and illustrated by two cases in which the roentgen appearances enabled the diagnosis to be made.

ZUSAMMENFASSUNG

Die Ätiologie und der klinische Verlauf eines Aneurysma dissecans der Aorta thoracica wird beschrieben und durch 2 Fälle illustriert, in welchen das röntgenologische Bild die Stellung der Diagnose ermöglichte.

RÉSUMÉ

L'auteur rapelle les causes et l'évolution clinique de l'anévrisme disséquant de l'aorte thoracique et donne comme exemples deux cas où les images radiographiques ont permis de faire le diagnostic.

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FROM THE MEDICAL DIVISION (DIRECTOR: M. BRUCER), OAK RIDGE INSTITUTE OF NUCLEAR STUDIES, OAK RIDGE, TENNESSEE, UNDER CONTRACT WITH THE UNITED STATES ATOMIC ENERGY COMMISSION

CALCIFICATION IN SECONDARY TUMORS OF THE SPLEEN

Report of a case

by

Constantin G. Papavasiliou

Calcification in tumors usually follows hemorrhage, necrosis, or degenerative changes, such as hyaline, mucoid, or fatty degeneration. Calcium deposition is usually considered a sign of a slow-growing malignancy or even of regressive processes taking place in the tumor. Often hyaline transformation, followed by calcification, leads to atrophy of part of the tumor, and, according to many authors, calcium inhibits the growth of the tumor cells. On the other hand, according to EWING, this does not hold true for papillary carcinomas of the ovaries and certain other 'psammocarcinomata' where an extensive 'psammomatous' type of calcium deposition is a part of an active growth and does not seem to inhibit progress of the tumor. Although calcification of a primary tumor is not an uncommon phenomenon, calcification of a metastatic tumor is rather rare. Although the lungs, peritoneum, and liver have been reported as the site of radiologically-seen calcified metastases, search of the literature failed to reveal any cases of calcified metastases in the

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Conventional film of the abdomen revealing several curvilinear calcifications in the spleen

spleen. We therefore report a case in which calcium deposition was present in a secondary tumor of the spleen from a primary pseudomucinous cystadenocarcinoma of the ovary.

Case report

A forty-eight-year old woman, a teacher, was admitted for the first time to our hospital in 1955 with an established diagnosis of a pseudomucinous cystadenocarcinoma of the ovary with peritoneal metastases. Roentgen therapy over the lower abdomen had been given; the patient, six months later, had developed ascites and she entered our hospital, mainly for radioactive gold (Au 198) treatments. Another exploratory laparotomy showed cystic masses spread all over the peritoneal cavity, and a total hysterectomy, bilateral salpingo-oophorectomy, and omentectomy were performed. Immediately after, the patient received 100 mC of Au 198 intraperitoneally, and was discharged.

During her second hospitalization, in August 1956, urography was performed, which showed a normal urinary tract but an enlarged spleen containing curvilinear calcifications (see figure above). No operation was performed at that time and the patient was discharged.

Since then, she has been periodically admitted to the hospital and three more exploratory laparotomies have been performed, part of the growing tumor having been resected each time. She has also received a course of external irradiation from a cesium 137 teletherapy unit over a mass in the right upper quadrant.

During her last admission, in July 1958, a conventional film of the abdomen showed again the splenic calcification and an additional curvilinear calcification. A splenectomy was performed. The spleen was found to be enlarged and it contained several cystic

masses of which some were calcified. Decalcified sections demonstrated the calcium deposition to have occurred in the superficial, more degenerated portion of the fibrous wall lining some of the cysts. The gross appearance of the cysts and their proximity to the outer aspect of the spleen suggested the possibility that a small implant in this region might have penetrated the capsule and expanded within the pulp of the spleen. It was felt that this was a more likely explanation than a hematogenous or lymphatic dissemination.

The pathologist reported the calcification to be a degenerative phenomenon and not evidence of calcification of the epithelium or formation of psammoma bodies. The final diagnosis was pseudomucinous cystadenocarcinoma of the ovary involving the spleen and the peritoneal surfaces. Some other granulomatous areas were found in the spleen; they were caused by a histoplasmic infection, but these granulomata were not calcified.

Discussion

Calcification in tumors of the abdomen has a diagnostic value from the roentgenological point of view. BATLAN reported a case and reviewed the literature of calcification in gastric tumors. In seven cases in which calcium was radiologically detected the tumor turned out to be a mucinous adenocarcinoma. KENDIG et coll. and recently PETERSEN presented another case of calcification in a mucinous adenocarcinoma of the stomach. I know of two more unpublished cases of calcification in gastric tumors similar to PETERSEN's case. In all these cases the calcification was of the punctate miliary type. LINGLEY, in 1942, reported five cases of ovarian papillary cystadenomata and cystadenocarcinomata where a uniform, minute, miliary type of calcification was present. LOUD and DEDICK and WHALEN and NATHANSON have reported cases of the same 'psammomatous' calcification in ovarian tumors. All of them were papillary cystadenomata or cystadenocarcinomata. In NATHANSON's case, the peritoneal cavity was also involved, as well as the liver and right pleural cavity, showing a psammomatous, nodular, and curvilinear type of calcification. WELLS reported three cases of a fine granular calcification, which occurred in liver metastases. The primary lesion was an adenocarcinoma of the colon. Since then, APPLEBY and HACKING have reported two similar cases.

Summarizing we would say that (1) calcification in gastric masses is indicative of a mucinous adenocarcinoma of the stomach, (2) minute miliary calcification in ovarian tumors suggests a papillary cystadenocarcinoma and (3) calcified liver metastases suggest a primary adenocarcinoma in the colon.

It is also well known that neuroblastomata of the adrenals often calcify, helping thus in the radiological diagnosis of these tumours.

Comment. Although calcification in the spleen may result from various lesions, including infections, infarcts, aneurysms, tumors, cysts, hemorrhage, abscesses, and phleboliths, no cases of calcified metastatic tumors have been reported. Generally, however, metastatic cancer of the spleen is considered rather rare, and there appears to be a discrepancy between the abundant blood supply and the apparently few metastases involving this organ.

In our patient, the calcification of the spleen was of the shell type, as though an attempt had been made to wall off the growth. The calcification, therefore, in our patient might represent a manifestation of the unfavorable environment of the spleen for some of the malignant growths.

The mechanism of the calcification is very obscure. BATLAN proposed the hypothesis that mucin, a glycoprotein, is a potentially calcifiable substance acting as an ion exchange resin. Hyaline and mucin appear to be chemically similar to the cartilage of the zone of calcification in the bones. Nevertheless, other factors play a role in calcium deposition and these are the action of phosphatase, pH, and the rate of blood circulation in the tissue.

SUMMARY

Description of a case in which shell-like calcification occurred in secondary tumors of the spleen from a primary pseudomucinous cystadenocarcinoma of the ovary.

ZUSAMMENFASSUNG

Der Verfasser beschreibt einen Fall, in dem schallenähnliche Verkalkungen in Milzmetastasen eines pseudomucinösen Zystadenocarcinomes des Ovariums auftraten.

RÉSUMÉ

Description d'un cas de calcification en coquille d'œuf dans des tumeurs secondaires de la rate provenant d'un cystadénocarcinome pseudomucineux de l'ovaire.

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COMMUNICATION BETWEEN THE ANTERIOR AORTIC SINUS AND THE RIGHT VENTRICLE DIAGNOSED BY THORACIC AORTOGRAPHY

by

Jan Philipson and *Georg-Fredrik Saltzman*

Roentgenography of the heart and great vessels with the aid of a contrast medium has considerably increased our knowledge of most of the congenital deformities in the centrally situated circulatory organs. In rare malformations with a left-to-right shunt near the aortic valves, such as aortic septal defects, ventricular septal defects with aortic incompetence, and ruptured aortic sinus aneurysms, thoracic aortography is an invaluable aid to diagnosis. The usefulness of this method in such deformities is well illustrated in the case now presented which resisted all attempts at diagnosis over a long period.

A little over 20 cases with a communication between the aortic bulb and the right ventricle have previously been described under the title of ruptured aortic sinus aneurysm (JONES & LANGLEY, and others). The majority of these cases were diagnosed at autopsy. It has not been made quite clear whether a ruptured aneurysm was actually found in every instance or whether in some of them the deformity was more to

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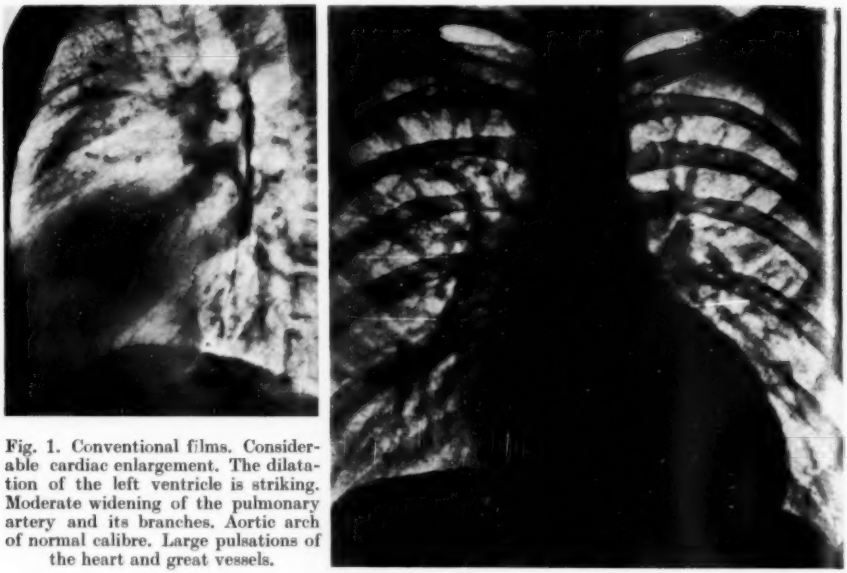

Fig. 1. Conventional films. Considerable cardiac enlargement. The dilatation of the left ventricle is striking. Moderate widening of the pulmonary artery and its branches. Aortic arch of normal calibre. Large pulsations of the heart and great vessels.

be regarded as a septal defect. KJELLBERG et coll. have made this diagnosis in two living subjects; in the one case the diagnosis was made with the aid of thoracic aortography and in the other after the injection of contrast medium into the pulmonary artery. In both cases a communication between the aortic sinus and the right ventricle was detected. DAVIDSEN et coll., using thoracic aortography, established the presence of an aneurysm of the anterior aortic sinus which had perforated into the right atrium.

In a previous paper on a combination of ventricular septal defect and aortic insufficiency we discussed the problems involved in the differential diagnosis between malformations near the aortic valves with left-to-right shunt. In that paper we stressed the value of thoracic aortography for differential diagnostic purposes. There were in the material presented two cases in which the diagnosis was not clear in all details but which closely resembled in their haemodynamic aspects other cases in which it had been possible to confirm a ventricular septal defect with aortic incompetence. We subsequently had an opportunity to perform a thoracic aortography in one of these two cases (Case 6), and could establish that a direct communication existed between the aorta and right ventricle, situated probably in the anterior aortic sinus (I. N. A. system).

Case report

Male, aged 34, artist. Congenital heart disease had been diagnosed in early childhood, but the nature of the deformity was not established at that time. Up to the age of 16 he had felt quite well, and his physical endurance did not differ from that of other children of the same age, but from then on he began to suffer from increasingly severe breathlessness after physical exertion.

At the age of 26 (1948), he was admitted for the first time for examination. A left-to-right shunt with transient auricular fibrillation was then detected. Thoracic aortography was attempted. The quality of the examination was unsatisfactory, but the left-to-right shunt was verified through the fact that a small amount of contrast medium had passed over into the pulmonary artery, probably at the base of the vessel. The left-to-right shunt was also confirmed by heart catheterization (see Table below), but owing to the fact that a blood test was unsuccessful, the exact site of the communication could not be determined at this examination either. As a continuous murmur was heard, however, a patent ductus arteriosus was suspected and thoracotomy was performed. It was then found that the anastomosis was situated close to the semilunar valves. Its nature could not be established beyond all doubt, but the surgeon (CRAFOORD) was inclined to think it was a ruptured aortic sinus aneurysm. The case was considered to be inoperable.

The patient's health varied after the operation. At times he had symptoms indicating mild incompensation, but these could be kept under control without much difficulty.

He was readmitted in 1955 so that another endeavour might be made to localize the shunt. He was found to be in good general condition; there were no manifest signs of incompensation, and no voussure. A strong continuous thrill was palpable all over the front of the thorax. On auscultation, a harsh, continuous murmur was heard; this was loudest in systole, and changed over without interruption to a diastolic murmur audible throughout diastole. The second sound was weak over the base of the heart. The heart rhythm was regular, and without extrasystoles. Blood pressure 130/50. Electrocardiographic examination revealed slow sinus rhythm. Left ventricular strain. At a heart function test the patient managed an easy task on Nylin's staircase without pathologically increased oxygen deficiency. Phonocardiography verified the auscultatory finding and revealed the presence of a continuous murmur with the systolic component much stronger than the diastolic. No second sound was recorded. Renewed heart catheterization showed that the mixing of oxygenated blood took place in the right ventricle. The pressure in the right ventricle and pulmonary artery was raised (cf. the Table).

During the whole period that we had the patient under observation the heart presented the same appearances in conventional roentgenograms (Fig. 1). The heart volume was 710 cc per m^2 of body surface at the last examination.

Table. *Catheterization of the heart*

Date	Oxygen saturation (vol.% O_2)				Blood pressure		
	Superior vena cava	Right atrium	Right ventricle	Pulmonary artery	Right atrium	Right ventricle	Pulmonary artery
14.1.48	10.3	10.4	—	12.8	14 cm H_2O	34 cm H_2O	25 cm H_2O
23.1.55	10.2	10.4	13.1	13.2	8 mm Hg	45/6 mm Hg	31/11 mm Hg

Fig. 2. Aortography, a. p. view. The contrast medium was injected into the ascending aorta. It passed over into the right ventricle; no other heart chambers filled.

Fig. 3. Aortography, lateral view. The exposure was made at the start of the injection in diastole. A small amount of contrast medium passed into the right ventricle and filled the pulmonary conus.

Aortography (Figs. 2 to 4). A catheter of the Ödman-Seldinger type was inserted into the arterial system so that its tip lay in the middle part of the ascending aorta and 85 ml Umbradil 70 % were injected approximately within three seconds. A large amount of the contrast medium passed over from the aortic bulb to the pulmonary conus. The width of the communicating passage could not be measured with exactitude; its diameter

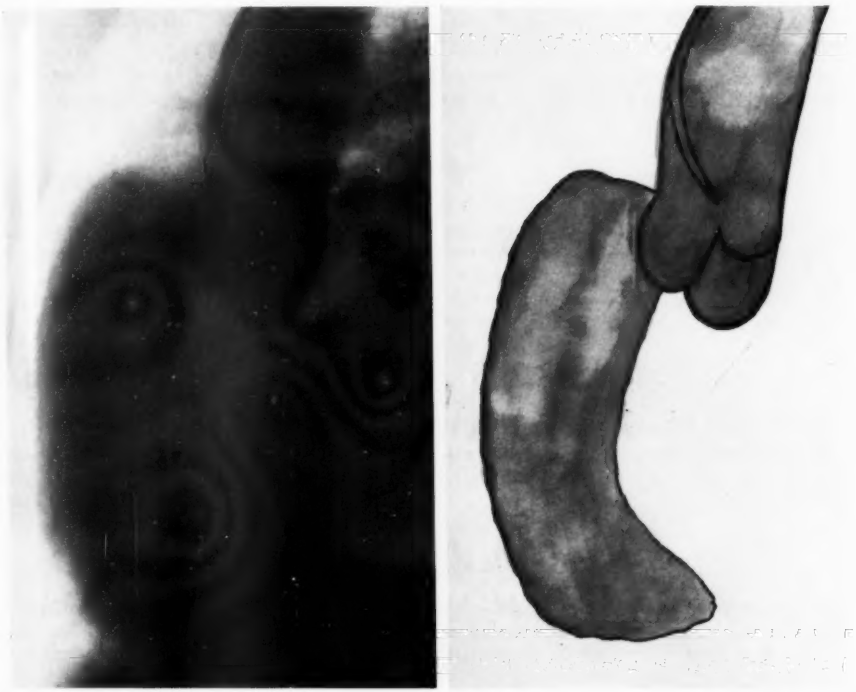

Fig. 4. Aortography, lateral view. The exposure was made towards the end of the injection in diastole. Contrast medium has passed over into the right ventricle and filled it; no other heart chambers filled.

was 1.5 cm at the most, but may have been narrower. Nor could its position in relation to the origins of the coronary arteries be exactly determined. In addition to the shunt, a local dilatation of the ascending aorta immediately above the sinus part was noted. No contrast medium was seen in the left ventricle and there was thus no insufficiency of the aortic valves. The pulmonary artery was dilated, having a diameter of 6 cm.

In an earlier paper we discussed the possibilities available for differentiating, both clinically and in conventional roentgenograms, between patent ductus arteriosus and cases with a left-to-right shunt situated close to the semilunar valves. Thoracic aortography is, however, the best method for achieving a correct diagnosis when a distinction is to be made between an aortic septal defect, a ventricular septal defect with aortic insufficiency, and a communication between the aortic bulb and the right ventricle. It is true that, as already mentioned, KJELLBERG et coll. demonstrated a communication between the aortic bulb and the right ventricle by means of selective angiocardiography, but it is our opinion that thoracic aortography gives better in-

formation regarding the anatomic details in the area in question. Because of the greater contrast density, thoracic aortography is the only conceivable alternative if the patient is full-grown. DAVIDSEN et coll. have also stressed the value of this method in the investigation of such cases.

Addendum

After this paper had been submitted for publication an attempt was made to close the communication between the aortic sinus and the right ventricle. The patient died after the operation. The anastomosis between the anterior aortic sinus and the right ventricle was verified at autopsy; it had a diameter of 3 to 4 mm. A defect of a little finger's breadth in the membranous part of the intraventricular septum was also found. No signs indicating aortic insufficiency were observed.

SUMMARY

The clinical data and roentgenologic findings in a case with left-to-right shunt from the anterior aortic sinus to the right ventricle are described. The differential diagnosis between various malformations with left-to-right shunt close to the aortic orifice is discussed.

ZUSAMMENFASSUNG

Die klinischen Daten und die röntgenologischen Befunde in einem Fall mit Rechts-Links-Shunt vom Sinus aortae anterior zum rechten Ventrikel werden beschrieben. Die Differentialdiagnose zwischen verschiedenen Missbildungen mit Rechts-Links-Shunt in der Nähe des Ostium arteriosum sinistrum wird diskutiert.

RÉSUMÉ

Les auteurs présentent les données cliniques et les signes radiographiques d'un cas de shunt de gauche à droite allant du sinus aortique antérieur au ventricule droit. Ils discutent le diagnostic différentiel entre les diverses malformations s'accompagnant d'un shunt de gauche à droite près de l'orifice aortique.

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ROENTGENOGRAPHIC FINDINGS IN TRIGEMINAL NEURALGIA

by

J. Bjerrum and *G. Thorneval*

Many theories have been advanced in the course of time to explain the pathogenesis of trigeminal neuralgia but the problem has not yet been finally solved.

In 1929 OLIVECRONA suggested that trigeminal neuralgia and glossopharyngeal neuralgia might be caused by traction on the nerves in their intracranial course, for from the brain stem to their fixed exit from the dura they proceed mainly downwards; the traction on the nerves was believed to be due to the conception that with advancing age the brain has a tendency to be displaced caudally.

LEE in 1937 found an analogy between meralgia paraesthetica of the lateral cutaneous nerve of the thigh and trigeminal neuralgia, and stated that both were due to traction on the respective nerves, both of which run an angular course in relation to firm bone. Meralgia paraesthetica is cured by freeing the lateral cutaneous nerve of the thigh from the tight fascial bands which fix it to the anterior superior iliac spine. LEE advanced the hypothesis that trigeminal neuralgia might be relieved by diminishing the traction on the root of the trigeminal nerve where it passes from the Gasserian ganglion by way of the petrous bone down to the pons. This, he said, could be done by chiselling off a portion of the apex of the petrous bone.

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Fig. 1. McGregor's line traced.

After TAARNHØJ in 1952 and 1954 reported the first results of his decompression operation, the discussion regarding the pathogenesis of the condition was revived. In the greater part (70 %) of a series with trigeminal neuralgia, WEBER (1954) found an abnormally deep posterior fossa. Its aetiology was stated to be in some cases hyperlordosis of the cervical spine due to osteochondrosis. In loading experiments on decalcinated skulls, he demonstrated that such postural anomalies cause deepening of the posterior fossa and upward displacement of the medial part of the petrous bone due to the basilar impression.

GARDNER et coll. in 1956 published a paper on the roentgenographic findings in trigeminal neuralgia. Like LEE they believe that it may be due to traction on the nerve where it crosses the petrous bone in the trigeminal impression, traction caused by elevation of the bony portion as a link in the basilar impression. In a number of posteroanterior films of the skull of patients with trigeminal neuralgia in which the petrous bone was projected through the orbits, they measured the distance from the trigeminal impression to a horizontal line touching the roofs of the orbits. This revealed that the trigeminal impression is at a higher level on the side of the trigeminal pain. Furthermore, they measured the relationship of the tip of the odontoid process to McGregor's line and found a larger basilar impression in patients with trigeminal neuralgia than in a corresponding normal series. This basilar impression was larger in elderly women than in elderly men, a phenomenon explained by postmenopausal

Fig. 2. Left-sided trigeminal neuralgia (in a male, 38 years). The left trigeminal impression is more high-seated than the right. Auxiliary lines traced.

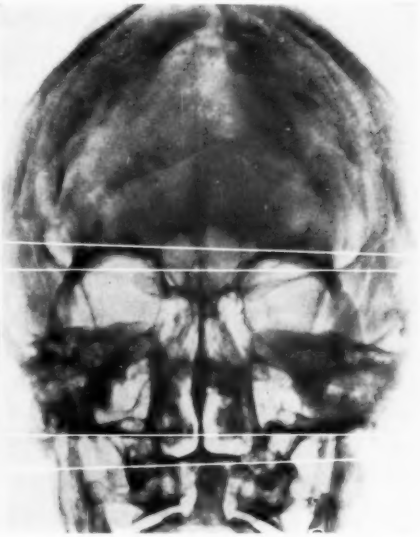

Fig. 3. 'Scoliotic' skull with non-parallel auxiliary lines but with an unmistakable difference in the level of the petrous bones.

osteoporosis. GARDNER and his associates also found an upward displacement of the petrous bone more common on the right side than on the left in normal subjects as well as in those with trigeminal neuralgia. This is explained as a result of a greater right-sided muscular traction on the skull in right-handed subjects; this traction is countered by an upward thrust of the spine on the central part of the base of the skull which actually tilts the apex of the petrous bone upwards.

Present investigations

In order to test the findings of GARDNER et coll. on a Danish series, we made similar measurements on roentgenograms of the skulls of all patients with typical trigeminal neuralgia admitted to the Neurosurgical Department during the period 1953—1957. This series comprises 76 patients, 21 of whom had to be excluded because the films were unsuitable for the measurements, mainly because the trigeminal impressions had not been projected through the orbits. Corresponding measurements were made in a control series of a similar age distribution, consisting of 100 patients without symptoms or signs of trigeminal neuralgia. The age distribution and sex ratio of the patients and the controls are given in Table 1.

Table 1

Age distribution and sex ratio

	Age distribution					Sex ratio	
	Under 40	40—49	50—59	60—69	over 70	Males	Femal s
Number of cases	5	7	10	13	19	21	34
» » controls ...	0	37	33	23	7	61	39

Table 2

Average values for level of odontoid process above McGregor's line

Age group	Controls	Trigeminal neuralgia
under 40		2.6 mm (5)
40—49	2.2 mm (37)	4.3 mm (7)
50—59	2.4 mm (33)	1.7 mm (10)
60—69	2.3 mm (23)	3.5 mm (13)
70—79	3.6 mm (5)	1.8 mm (19)
over 80	0.0 mm (2)	
Entire series	2.3 mm (100 Cases)	2.6 mm (54 Cases)

Table 3

Variations in level of trigeminal impression

	Right above left	Right = left	Left above right
R-sided trigem. neuralgia	17	3	6
L-sided trig. neuralgia	4	6	11
Bilateral trig. neuralgia	1	5	2
Controls	37	30	33

Measurements of the basilar impression. Like GARDNER et coll. we assessed the basilar impression from the level of the odontoid process in relation to McGregor's line (Fig. 1). Since the views were not always absolutely true ones, and since a certain degree of distorsion must be expected due to a short focus—film distance, the measurements made were only accurate to within 2 mm.

Measurement of the level of the trigeminal impression. Since several skulls of our series proved to be associated with rather marked scoliosis, we felt we could not be content with the auxiliary line through the orbital roof described by GARDNER et coll. In the attempt to make the investigations more exact, we used a series of transverse auxiliary lines through various levels in the skull (Fig. 2 a). These consisted of:

I. The line of GARDNER et coll., through the orbital roof.

II. A line through the points of intersection of the sphenoid ridge and the great wing of the sphenoid bone (only applicable when the views are absolutely true).

III. A line through the apices of the mastoid processes.

IV. A line touching the base of the skull inferiorly (only applicable when the base is sufficiently flat).

We tried to trace as many of these lines as possible in our films, but in several cases we had to omit one or more lines the direction of which differed markedly from the others. Fig. 3 exemplifies a 'scoliotic' skull in which the measurement is difficult, there being an unmistakable difference in the levels of the petrous bones.

Results

Our measurements of the basilar impression are shown in Table 2. It will be seen that in the normal series there was a slightly increasing basilar impression with advancing age. In the series with trigeminal neuralgia, the numbers involved are rather too small to permit conclusions, but at any rate the results do not show any definite agreement with the findings of GARDNER et coll. although the average basilar impression among the patients was somewhat larger than among the controls.

The measurements of the level of the trigeminal impression are more in accordance with the results of the authors just mentioned. An attempt is made to illustrate the measurements in a number of diagrams in which the ordinates indicate the number of patients and the abscissae the level of the right trigeminal impression in relation to the left, measured in millimetres.

Diagram 1 shows the level of the trigeminal impression in our normal series. There is only a negligible dispersion around zero value (equal level of trigeminal impressions), and the slight tendency to a higher level of the trigeminal impression on the right side is not statistically significant. Diagrams 2, 3 and 4, in the same way set out the series with right-sided, left-sided, and bilateral trigeminal neuralgia, respectively. Diagrams 1 and 2 show that the trigeminal impression has an unmistakable tendency to be at a higher level on the affected side. Since, however, the numbers involved are relatively small, the results were submitted to statistical calculation. This showed that in unilateral cases the difference

was statistically significant when, instead of the product: number of patients × difference in level, the number of patients is evaluated in relation to zero point. This mode of assessing seems to be reasonable, since the presence of a difference in level must be more important than its size. Table 3, therefore, gives the number of patients in the individual groups: out of 8 cases of bilateral trigeminal neuralgia, 5 had equally high trigeminal impressions.

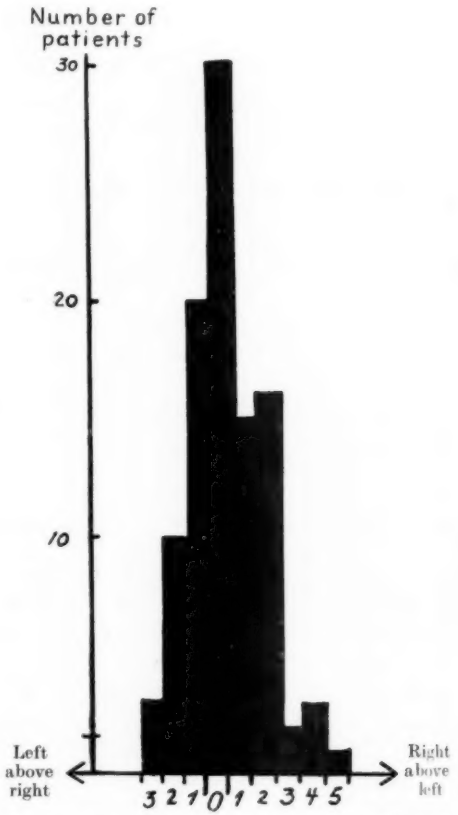

Diagram 1. Normal series. Abscissa shows difference in level of petrous bones (0 indicating equal level).

Discussion

Like GARDNER et coll. we found a marked tendency for the trigeminal impression to be situated higher on the affected side in patients with unilateral trigeminal neuralgia. On the other hand, we could not confirm these authors' findings of an increased basilar impression in cases of trigeminal neuralgia. We are more inclined to consider the difference in the level of the trigeminal impressions on the two sides as an anatomic variant which may decide the localization of trigeminal neuralgia when traction is exerted on the nerve for some other reason. As stated by OLIVECRONA, such traction may be assumed to arise due to the caudal displacement of the brain in elderly persons. Our investigations then explain why this may result in unilateral and not bilateral neuralgia, as the traction on the nerve must be more marked on the side upon which the trigeminal impression is at a higher level.

GARDNER & PINTO presume that traction on the sensory root of the trigeminal nerve may cause degenerative changes in the myelin sheath,

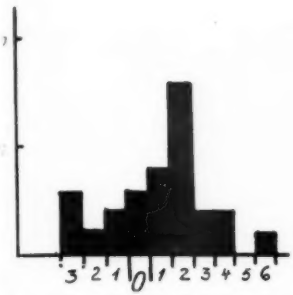

Diagram 2. Patients with right-sided trigeminal neuralgia.

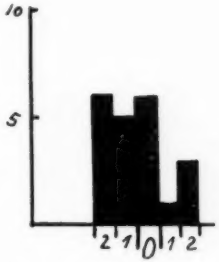

Diagram 3. Patients with left-sided trigeminal neuralgia.

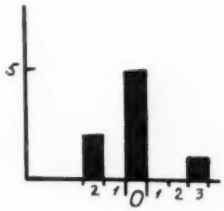

Diagram 4. Patients with bilateral trigeminal neuralgia.

from which abnormal action potentials may develop, explaining the typical lightning stabs of pain and believed to be elicited by irritation in the trigger zone. This is supported by the findings of BISGAARD & ERNA CHRISTENSEN; in the course of pathologic examination of the Gasserian ganglion in a small series of patients with trigeminal neuralgia, in the majority of cases they found microscopic changes consisting in arachnoid proliferation, endoneurial proliferation, and atrophy of the nerve cells.

SUMMARY

Special measurements of the skull were carried out in a series of 55 patients with typical trigeminal neuralgia and 100 controls. It was found that the trigeminal impression at the apex of the petrous bone showed an unmistakable tendency to lie at a higher level on the affected side. This is taken to support the theories which explain trigeminal neuralgia as the result of traction on the sensory root of the trigeminal nerve.

ZUSAMMENFASSUNG

Spezielle Schädelmessungen wurden an 55 Patienten mit typischer Trigeminusneuralgie und an 100 Kontrollpatienten durchgeführt. Man fand, dass die Trigeminusimpression an der Spitze des Os petrosum eine unverkennbare Tendenz zeigte, auf der erkrankten Seite höher zu liegen. Dieser Befund stützt die Theorien, welche die Trigeminusneuralgie als die Folge eines Zuges an der sensorischen Wurzel des Nervus trigeminus erklären.

RÉSUMÉ

Les auteurs ont fait des mensurations spéciales sur le crâne, sur une série de 55 malades atteints de névralgie trigéminale typique et sur 100 sujets de contrôle. Ils nt constaté que l'échancrure trigéminale à l'apex du rocher a une incontestable tenda ce à être située à un niveau plus élevé du côté malade. Ils pensent que ce fait vient à l'ap ui des théories qui expliquent la névralgie trigéminale par une traction sur la racine sensi ve du trijumeau.

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ROENTGEN-TELEVISION EQUIPMENT FOR USE IN SURGERY

by

Henry Wallman and *Ingmar Wickbom*

The technical aim in roentgenologic examinations usually consists in obtaining images of satisfactory contrast containing as much detail as possible. In certain cases, however, the need is for rapid information, even if the roentgenogram obtained shows only limited resolution. This is frequently the case in examinations carried out during surgical procedures, *e. g.* during the reduction of fractures, with or without osteosynthesis, during the search for foreign bodies or renal calculi, or for the purpose of orientation in transsphenoidal hypophysectomy. For such applications fluoroscopy has advantages over roentgenography, and was in fact formerly employed for this purpose; its use was later abandoned, partly because the eyes of the examiner had to be adapted to darkness and even more by reason of the radiation hazards involved.

An image intensifier (6) may be used to obviate the need for light adaptation with normal dose rates or, alternatively (7), if the examination is carried out in a dimly lit room, to permit a dose reduction by a factor of about 10. The radiation hazards which remain cannot, however, be neglected as the examiner has to stand fairly close to the roentgen tube

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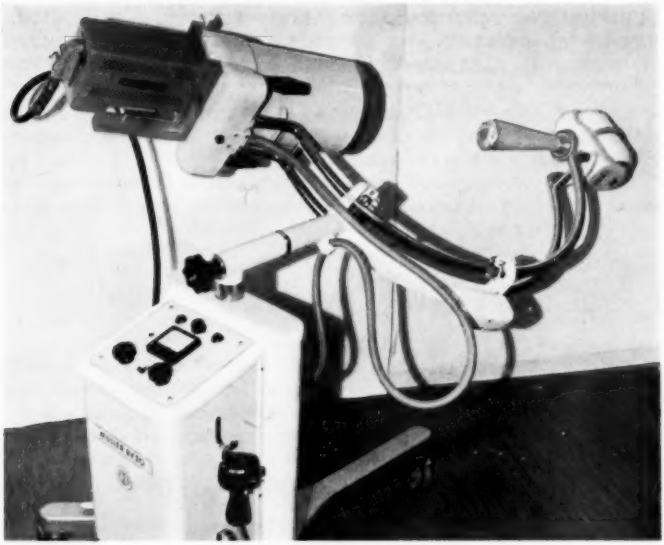


Fig. 1. Combination of Müller BV-20 image intensifier roentgen equipment and Fernseh closed circuit vidicon television camera.

and may even inadvertently come within the path of the rays. Most surgeons, at least in Sweden, refrain from using fluoroscopy, including image-intensifier fluoroscopy, for this reason.

A roentgen-television method (2, 3, 4, 5), in which the fluoroscopic image is conveyed to a television picture tube, possesses the following three advantages: with the television tube placed several metres from the path of the roentgen rays, the radiation danger to the examiner is eliminated: the brightness level of the television screen permits the examination to be carried out in ordinarily lighted rooms; the relatively large size of the television picture enables the surgeon and roentgenologist to examine and discuss the appearances together.

The authors of this paper have been engaged for some time in a research program devoted to developing roentgen-television equipment suitable for practical employment in the operating room. The equipment to be described has so far been employed only in the laboratory: work towards its clinical utilization is now proceeding and, it is hoped, will form the subject of a subsequent article. The second part of the present paper, describing the use of 'storage' (or 'memory') picture tubes, is believed to represent a particularly important advance in roentgen-television technique.

a b

Fig. 2. Fluoroscopic images at 65 kV, 3 mA, transmitted to the screen of an ordinary television tube. In (a) the fine detail in the spongy bone is just visible. In (b) a vitallium screw inserted 9 years previously is seen.

I. A roentgen-television system with image intensifier and vidicon camera

The combination of a Müller BV-20 image intensifier roentgen equipment with a Fernseh GmbH closed circuit vidicon television camera (Fig. 1), with the ultimate image displayed on the screen of an ordinary television tube, was first investigated. The scope of application of the combination is limited by the rather small field of view of the image intensifier (diameter 12.5 cm) and the relatively low voltage and current available (75 kV half-wave and 3 mA) from the roentgen unit, which precludes the examination of thick parts of the body, such as the hip. A further technical weakness lies in the fact that the particular image intensifier tube has its output screen placed in a rather deep tunnel; this necessitates the use of an optical system of comparatively small aperture (f/1.5) between the image intensifier and the television camera tube and therefore wastes an unnecessarily large part of the luminance amplification provided by the intensifier tube. Within its limitations, such as the examination of the extremities, the system has given encouraging results. The three goals mentioned previously for a roentgen-television system in the operating room are achieved, and the quality of the image obtained on the television screen would appear to be adequate for the reduction of fractures and nailing (Fig. 2).

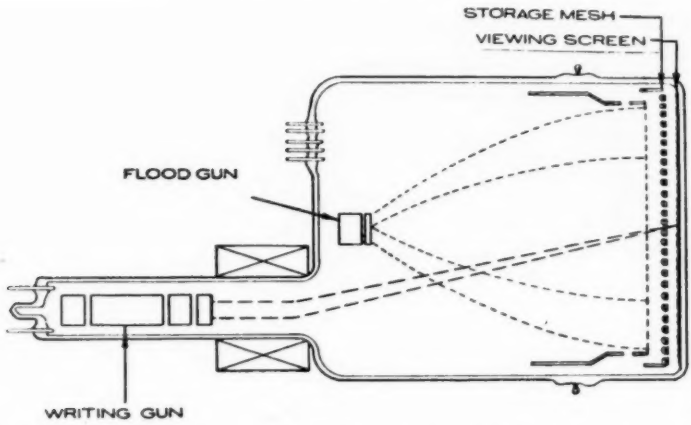
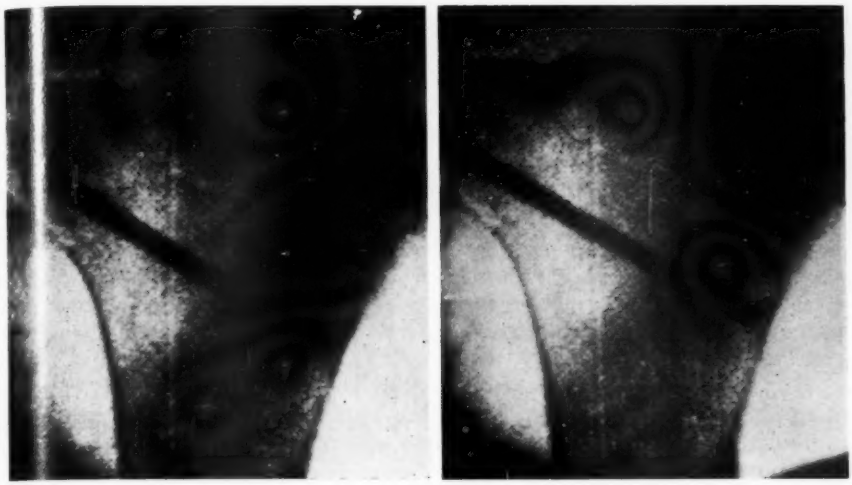


Fig. 3. Schematic illustration of the internal construction of the Tonotron storage tube.

II. A roentgen-television system with an image storage tube

The advantages of combining image storage with fluoroscopy. When brightness intensification of fluoroscopic images was first proposed (1), it was thought that intensification would permit indefinite reduction of the roentgen dose in fluoroscopy. It is now well appreciated (9), (10), however, that a fluoroscopic image can never display better quality than that permitted by the statistical fluctuations in the number of roentgen quanta effective at the fluoroscopic screen per picture element per 0.1 sec (the accumulation time of the eye). Even if unlimited brightness intensification were available, high quality fluoroscopy would still require a certain minimum dose rate, that is, a certain minimum number of r per 0.1 sec. In a fluoroscopic examination this dose rate has to be maintained for much longer than 0.1 sec, sometimes up to several minutes, in order to allow time for a detailed examination of the fluoroscopic appearances. A very substantial dose reduction would be achieved by a storage system which 'froze' the fluoroscopic image obtained in 0.1 sec (or less) for subsequent examination for one or several minutes. (Such a storage system is of course provided by roentgenography, which therefore permits considerably lower mAs values than fluoroscopy. The value of an electronic system clearly lies in the instantaneous availability of the image.)

The method of fractional-second roentgen exposure and minute-long electronic storage to be described below is clearly inapplicable to the study of dynamic phenomena, such as the motility of the stomach wall, but within the range of its applicability — the study of static phenomena — it permits of a very large dose reduction factor over ordinary fluoroscopy.



a b

Fig. 1. Television-transmitted roentgen views displayed on Tonotron, at 75 kV, 3 mA, 0.04 sec (0.12 mAs), of knee phantom with nail a) 20 sec, and b) 40 sec after the same roentgen exposure.

Image storage tubes. Storage (or memory) picture tubes (8) have long been a goal of television technique. Ideally such a tube would permit rapid writing-in of a picture in, for example, 0.04 sec, storage of the image for long periods of time without loss of quality, and rapid erasure of the picture when required. The problem is far from solved but some progress has been made and a number of image storage tubes have recently become available. Two storage tubes of the 'Tonotron' type, manufactured by the Hughes Aircraft Company, California, were acquired by the Division of Teletechnique of Chalmers University of Technology in February 1957 for use in storage roentgen-television work.

The Tonotron (Fig. 3) has two electron guns, one a writing gun and the other a flood gun. The former impresses a charge pattern in a very short time, *e. g.* 0.04 sec, on a fine mesh placed at the 10 cm diameter viewing end of the tube. The image is latent (invisible) until the mesh is sprayed by a diffuse electron beam from the flood gun. The charge pattern is thereby electronically 'developed' to a visible image; the electronic development can take place immediately after the picture has been written-in or, if desired, some minutes later. The luminance of the visible image is very high — 5,000 asb — which permits viewing in brightly lit rooms, or projection to a diameter of 25 cm or more. The image persists

for about 60 sec, gradually losing contrast and detail, very much like a badly fixed print. By pulsing the flood gun the storage time can be increased to about five minutes; the image luminance is then reduced to 500 asb, about that of a bright television image. The Tonotron thus has characteristics of electronic photography in that it displays the phenomena of a latent image and the development of the latent image into a visible (but poorly fixed) picture. The Tonotron has one useful feature not shared by ordinary photography: the developed image can be instantaneously returned to its latent state, simply by turning off the flood gun.

The latent image (charge pattern) can be removed and the Tonotron prepared for a new picture in between 0.05 and 0.5 sec, depending upon the Tonotron potentials.

Tonotron resolution is limited by the structure of the mesh. By careful attention to numerous details ROLAND MALVÉN of Chalmers University of Technology has been able to achieve a resolution of 580 television lines (290 optical lines) across the diameter of the Tonotron face. Although this figure is only about half that for ordinary (non-storage) cathode ray tubes, it exceeds the resolution capabilities of the Philips image intensifier, for which a resolution of $16\,^2/_3$ optical lines/cm, that is 210 optical lines across the diameter of the intensifier, has been reported (7).

Unlike certain other storage tubes, the Tonotron reproduces tones of grey (hence the name); the number of distinguishable tones is, however, only five, which is half the number obtainable with ordinary television tubes. The Tonotron has also the disadvantages of being considerably more expensive and much more critical both in regard to operating potentials and the need for magnetic shielding than ordinary television tubes.

A Tonotron roentgen-television system. The roentgen-television system described above (roentgen unit, image intensifier and Vidicon camera) was combined with a Tonotron display unit (Tonotron plus amplifiers, sweep circuits, and gating circuits) and a central electronic synchronizing control. The system has three pushbuttons:

Expose: This triggers a single roentgen exposure, during which the roentgen image, intensified by the image intensifier, is focused on the vidicon. After this the vidicon is scanned for 0.04 sec and the electric signal so obtained is simultaneously written-in on the Tonotron storage mesh. The roentgen image is now latent on the Tonotron.

Develop: The Tonotron flood gun is turned on. The roentgen image is now visible on the Tonotron and remains so for about 60 sec without pulsing, or 5 min with pulsing.

Erase: The latent image is removed and the Tonotron is cleared for a new exposure.

Several minutes may elapse, if desired, between pressing pushbuttons '*expose*' and '*develop*', or the buttons may be so coupled that '*develop*' immediately follows '*expose*'. It is also possible to release pushbutton '*develop*' after, say, 15 sec to postpone for some minutes the remaining image storage time; this does not require a new roentgen exposure.

One of the objects investigated with the Tonotron roentgen-television system was a knee phantom with soft tissues simulated by Mix D. Roentgenography of the phantom with standard exposure data showed the phantom to possess absorption characteristics identical with those of a knee of a living subject. The illustrations in Fig. 4 show the Tonotron screen 20 sec and 40 sec, respectively, without pulsing, after a single 0.04 sec roentgen exposure of the knee phantom at 75 kV and 3 mA.

The following critical comments may perhaps be made:

1. Image degradation is small until about 40 sec of storage time without pulsing, 3 min with pulsing, have elapsed.

2. Image quality, although very much inferior to that of roentgenography and quite insufficient for the requirements of normal roentgen diagnosis, should be adequate for the control of the reduction of fractures.

3. The roentgen dose to the examiner is zero and the dose to the patient is very small.

SUMMARY

The authors describe their investigations with two roentgen-television systems, with image intensifier and vidicon camera, one with an ordinary television picture tube and the other with a Tonotron storage picture tube. The application of these systems is discussed as offering promises of advances in diagnostic roentgenology and as being of immediate value, say, in the control of the reduction of fractures.

ZUSAMMENFASSUNG

Die Autoren beschreiben ihre Untersuchungen an zwei Röntgen-Fernsehsystemen mit Bildverstärker und Vidikonkamera, das eine mit einer gewöhnlichen Bildröhre und das andere mit dem Tonotron, einer Bildspeicherröhre. Die Anwendung dieser Systeme, welche Fortschritte in der Röntgendiagnostik versprechen und bereits jetzt klinisches Interesse haben, z. B. für die Kontrolle der Einrichtung von Frakturen, wird diskutiert.

RÉSUMÉ

Les auteurs décrivent leur étude expérimentale de deux systèmes de roentgent évision constitués d'un intensificateur d'image et d'une caméra vidicon, équipés, l'un d un tube de télévision ordinaire, l'autre d'un Tonotron, tube mémoire d'image. Les aut rs examinent l'application de ces systèmes qui permet d'espérer d'importants progrès en diagnostic radiologique et qui a un intéret immédiat, par exemple pour le cont le de la réduction des fractures.

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IMAGE CONTRAST

A factor to be considered in the determination of layer thickness in tomography

by

Pekka Vuorinen

Metal phantoms are commonly used as test objects in tomographic experiments, especially when the 'layer thickness' is to be measured (1 to 4, and 7). SPIEGLER has shown (5,6) that too high a contrast in roentgenography may produce a false impression of sharpness, *e. g.* a metal object may be moved several millimeters during the exposure, but the resultant motional blurring is evident only if the contrast is not unduly raised.

An experiment was carried out to test this principle in tomography. An iron-wire grid was placed on a wedge-shaped piece of plastic foam which held it at an angle of approximately 45° to the plane of the film. A sheet of aluminium was placed under one half of the grid to reduce the photographic contrast on that part of the film. The test arrangement is shown in Fig. 1. A single tomographic exposure was made with the Siemens Universal-Planigraph. Part of the resultant film together with an explanatory drawing is shown in Fig. 2. It is obvious that with low contrast (the lighter part of the film) the thickness of 'sharp cut' is really much thinner than might be expected from an examination of the darker, or high-contrast part of the film.

In the light of this experiment it seems necessary to pay due consideration to the image contrast when tomographic tests with metal phantoms are carried out, for the results may otherwise be misleading.

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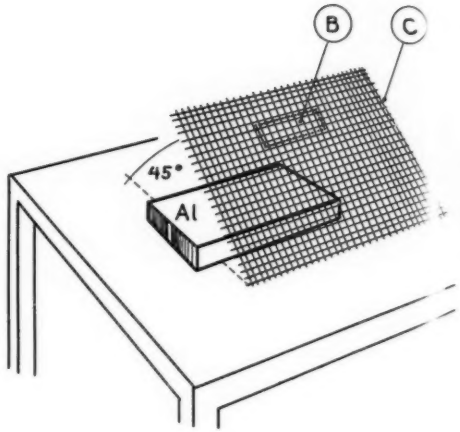

Fig. 1. Test arrangement. Metal grid at 45° to film plane.

C — tomographic cut,
B — area recorded in fig. 2,
Al — aluminium covering part of film.

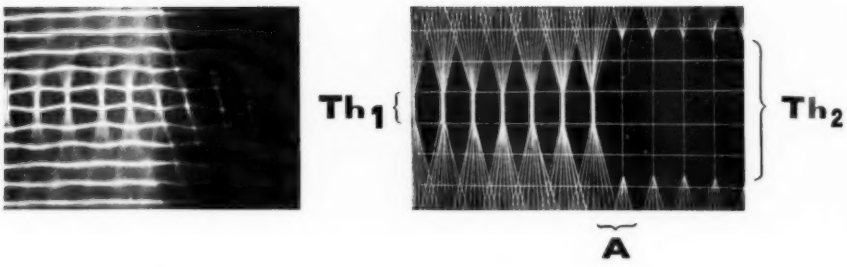

Fig. 2. a) Tomographic film of an oblique metal grid obtained as shown in fig. 1. b) Schematic drawing of sharpness and blurring of metal threads recorded on same film. Th 1 — thickness of area filtered by aluminium, Th 2 — the same of unfiltered area. In the lighter part of the film where the contrast between aluminium sheet and grid is low, the thickness of the 'sharp cut' is much less than in the darker part of the film where the image contrast is high.

SUMMARY

It is shown that the measurement of the thickness of a 'cut' in tomography by means of a metal grid may produce misleading results. A considerable reduction in the image contrast of the test roentgenogram is indicated in certain cases.

ZUSAMMENFASSUNG

Der Verfasser zeigt dass man irreführende Ergebnisse erhalten kann, wenn die Schnittdicke bei der Tomographie mit Hilfe eines Metallgitters gemessen wird. Um zuverlässige Resultate zu bekommen, ist es in gewissen Fällen notwendig, den Kontrast im Test-Röntgenogramm bedeutend zu reduzieren.

RÉSUMÉ

L'auteur montre que les résultats de la mesure de l'épaisseur de la couche de coupe en tomographie par la méthode de la grille métallique peuvent être trompeurs. Pour obtenir des résultats exacts, il est nécessaire dans certains cas de réduire considérablement le contraste pour les essais radiographiques.

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METHOD FOR IRRADIATION OF PARASTERNAL LYMPH-NODE METASTASES

by

F. Edsmyr and *R. Walstam*

In many recent papers on carcinoma mammae great attention has been paid to the risks of metastases within the parasternal region, and different methods of treatment both surgical and radiological have been discussed. The occurrence of parasternal metastases has been studied from the surgical standpoint, as well as on section material. Certain connections in regard to the situation of the primary tumour and the occurrence of axillary metastases have also been reported; in a study of the lymph drainage from the breast HULTBORN et coll. (1955) have quoted a number of anatomical and clinical observations published prior to 1955.

Some of the investigations already published have recently been studied by HULTBORN and TÖRNBERG. Their observations are summarized in Table 1.

As regards the situation of the primary tumour the different authors have not used the same principles of subdivision; the materials are therefore not quite comparable, and the summary in Table 2 may thus be considered as only approximate.

It is evident from Table 2 that the probability of parasternal metastases is greater if the primary tumour is situated in the medial or central part

Submitted for publication 9 July 1958.

Table 1

Relationship between the occurrence of parasternal metastases, the situation of primary tumours, and the presence of axillary metastases. (After HULTBORN & TÖRNBERG.)

Author	Situation of primary tumour	Axillary glands free			Axillary glands invaded		
		Number of cases	Number of parasternal metastases	%	Number of cases	Number of parasternal metastases	%
DAHL-IVERSEN	Medial	161	20	12	116	70	60
HANDLEY	Central	54	3	6	55	31	56
URBAN	Lateral	185	12	6	160	40	25
HUTCHINSON	Medial & central	15	1	7	5	3	60
	Lateral	25	1	4	36	16	44
MARGOTTINI & BUCALOSSI	Medial	20	0	0	27	9	33
	Lateral	23	2	9	36	11	31
HULTBORN & TÖRNBERG	Medial	9	1	11	10	6	60
	Central	6	0	0	5	2	40

of the breast than in the lateral part. Certain investigations have also shown differences as regards lymph-node metastases in medially and centrally situated primary tumours. These differences are shown in Table 1.

As regards the situation of the chain of parasternal metastases these investigations indicate that most of these metastases have been found in the second to fourth intercostal spaces. According to HAAGENSEN the lymph glands are not covered by cartilage and bone due to the close adhesion of the fascia endothoracica to the ribs and sternum. When working out the methods of treatment described below an investigation was carried out at Karolinska Sjukhuset on a very limited section material (8 cases) in order to determine the situation of the parasternal metastases; it was found, in agreement with information already published, that the

Table 2

Summary of the material in table 1

Situation of primary tumours	Axillary glands free			Axillary glands invaded		
	Number of cases	Number of parasternal metastases	%	Number of cases	Number of parasternal metastases	%
Medial & Central	265	25	9	218	121	56
Lateral	233	15	6	232	67	29

chain of glands is confined to a region less than 4 cm wide centered on the sternal border (Fig. 1).

The depth of the chain of glands below the skin surface has also been investigated, and has been found to be up to 3 to 4 cm in the fossa supraclavicularis but decreasing inferiorly to become only about 2 cm in the third and fourth intercostal spaces in normal subjects.

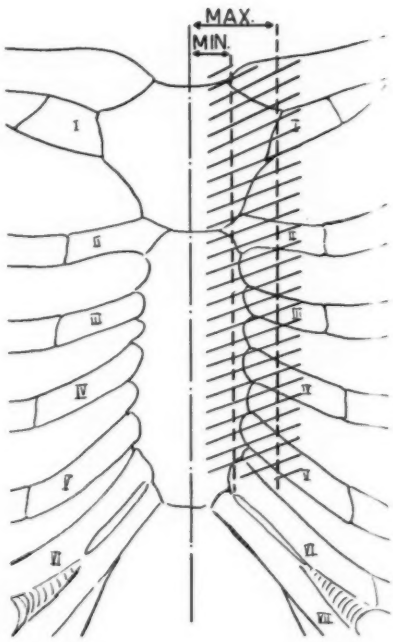

Fig. 1. The position of parasternal metastases in a section material of 8 cases. 'Max' and 'min' indicate the borders between which the position varies and the sectioned area indicates the position of the parasternal telegamma field (width about 4 cm).

Technique

The treatment of the chain of parasternal glands has been carried out by a number of surgical and radiological methods. At Radiumhemmet conventional roentgen irradiation has mainly been employed with a focus skin distance of about 50 cm and a radiation quality with a half value layer equal to approximately 0.8 mm Cu. There will often be considerable skin reactions and effects upon the lungs with such treatment even with quite moderate radiation doses. The skin reaction becomes specially marked in the regions where the skin layer above the bone tissue is thin; the radiation dose within the lung tissue is so great that the effects upon the lungs may be readily explained. The depth dose distribution obtained within the central parts of a homogeneous treatment area and under the conditions indicated with a skin dose of 3,000 r is shown as a comparison in Diagram 2. From our experiences at Radiumhemmet we have noticed that such a treatment, completed in about 14 days, often produces marked skin and lung reactions.

Clinically proved, late metastases in the topic area were previously often treated by radium units which, compared with conventional roentgen treatment, have the following advantages:

1. Selective bone absorption is avoided by using hard γ-radiation.

2. The radiation dose in the lung tissue is reduced considerably by using a short distance.

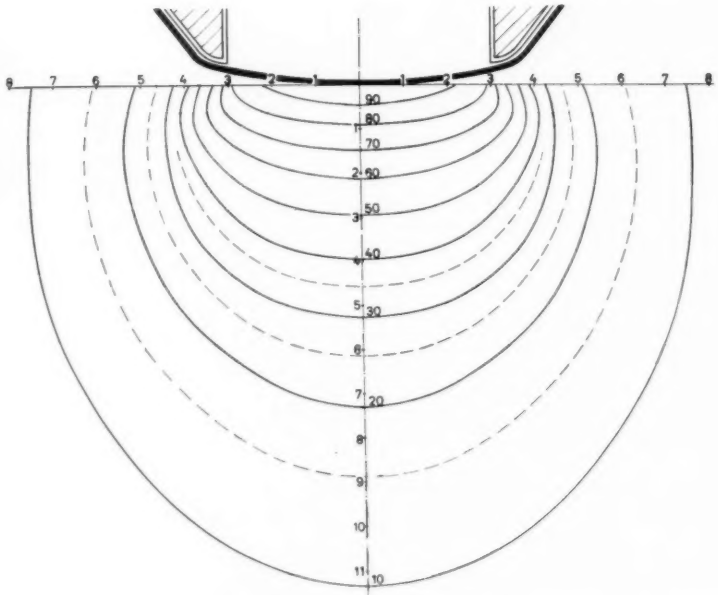

Diagram 1. The dose distribution of the 5 g Ra unit at Radiumhemmet. The relative depth dose is given as a percentage of the extrapolated surface dose.

3. A high extrapolated skin dose is very well tolerated by the patient due to the fact that the skin sparing dose distribution of MeV therapy can be maintained by a suitably designed treatment tube.

Upon the suggestion of JACOBSSON teleradium therapy together with other post-operative radiation therapy were introduced in 1954, in certain cases, more regularly for the treatment of the parasternal area.

With a 5 gram radium unit, the dose distribution of which is shown in Diagram 1, a radiation dose of 3,000 to 3,500 r is obtainable at a tissue depth of 2 cm with a distance of 7 to 8 cm between the centers of the fields and a recommended skin dose of 5,000 r/field. It should be noticed in this connection as well as in the following discussion that for technical reasons both the dose recommended for the field and the total skin dose are expressed in terms of the dose extrapolated to the skin. Recent measurements indicate that the true maximum dose lies at 2 to 3 mm tissue depth and amounts to 90 to 95 % of the reported value; in the external skin layer the dose would be 70 to 80 % of the extrapolated surface dose value.

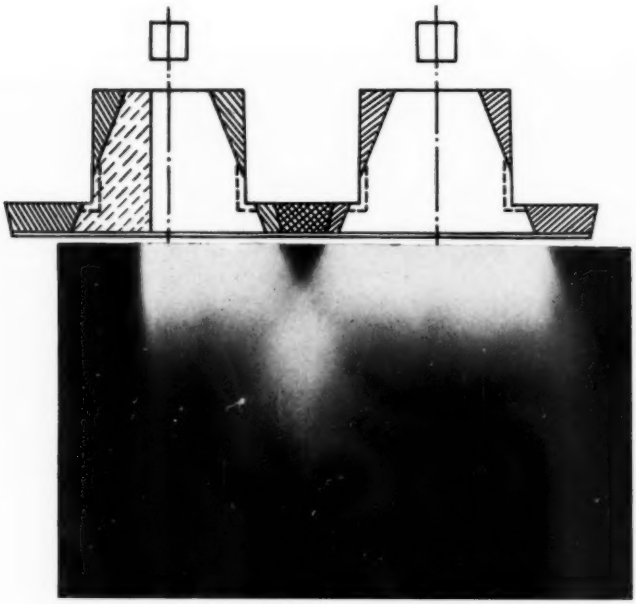

Fig. 2. Subcutaneous hot spots when combining two fixed treatment fields and using the parasternal tube of Radiumhemmet. The distance between the field centers is 8 cm; the beam nozzle to the left is provided with a lead insertion.

The diffuse radiation beam of the radium unit will, of course, result in considerable inhomogeneities with regard to dose distribution within the treatment area and in a considerable dose volume in the surrounding tissues. In order to eliminate these inconveniences treatments with the new decacurie apparatus for Co^{60} started in 1955 (DAHL et coll., LINDELL et coll.). This apparatus offers possibilities of well-defined radiation beams. A first series (Group A below), comprising 38 patients, was treated during the period December 1955 to September 1956 with the ordinary treatment tubes. The distances between the cobalt source and the skin (SSD) in this series was 10 cm and the width of the treatment area at the skin surface was about 6 cm; at a depth of 10 cm the width was 12 cm. With an extrapolated skin dose of about 4,500 r the radiation dose was about 3,700 r at a depth of 3 cm and about 2,000 r at a depth of 10 cm. A depth dose curve for this method of treatment is given in Diagram 2, for comparison.

In order to adapt the dose distribution better to clinical requirements, a special parasternal tube has been designed, based upon the observations

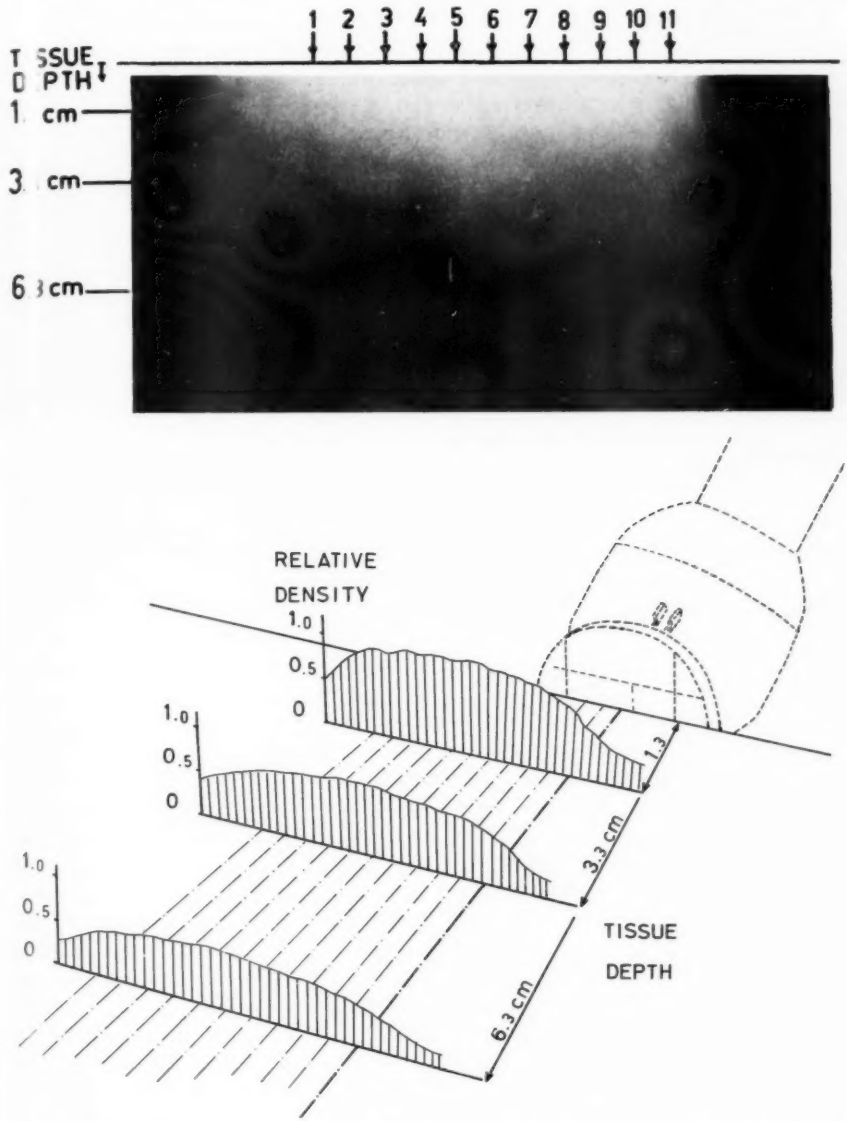

Fig. 3. The dose distribution in the longitudinal direction of the treatment field in the 'overlapping fields' technique. The same radiation dose has been given on each of the eleven treatment fields with the parasternal tube; on fields 10 and 11 the lead insertion indicated in fig. 2 was used.

The results of the density measurements carried out on the photographic negative are shown in the diagram (the lower part of the figure). The variations in doses depend on the overlapping of the fields and are negligible even at a tissue depth of only 1.3 cm.

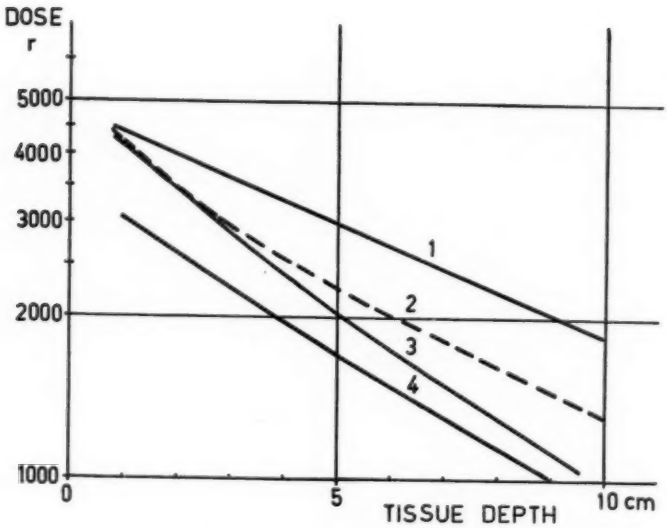

Diagram 2. Comparison between the depth dose distribution with different treatment methods, based on dose distribution measurements carried out in tissue equivalent phantom material.

1. Telegamma treatment 'overlapping fields' — SSD 10 cm
2. » » » » — SSD 6 cm
3. » » 5 g Ra unit two fields — distance 8 cm
4. Roentgen HVL = 0.8 mm Cu FSD 50 cm

regarding the position of the chain of glands made above. The construction of the treatment tube and the dose distribution obtained by this beam nozzle are shown in Fig. 2.

With due regard to the clinical observations, 3.5 cm has been chosen as the width of the area at the surface, and 6 cm for the SSD, the latter in order to ensure a rapid decrease of the dose in the lung tissue. It has been necessary to limit the length of the treatment area to about 6 cm but the well-defined radiation beam is divergent in the longitudinal axis of the area, as shown in Fig. 2. To cover the whole length of the treatment area it has been necessary to employ a treatment technique with several fields.

It is obvious that radiation beams of this type cannot be combined as easily as the diffusely irradiated volume in radium treatment (WALSTAM); with fixed fields, centered at a distance of, for instance, 8 cm, there will be both non-irradiated areas at the surface and subcutaneous hot spots (Fig. 2). A completely even dose can only be obtained if the radiation beam is permitted to scan the treatment area continuously; special arrangements must also be undertaken in order to equalize the radiation distribution where the treatment area starts or ends.

An overlapping field radiation of that kind can be reproduced by our 'overlapping fields' technique. The treatment area is divided into the necessary number of fields separated by a distance of only 1 cm upon each of which only one treatment, with a few exceptions, is given. A great number of hot spots of the type shown in Fig. 2 is obtained but since every hot spot is added to a comparatively high dose level, the variations in doses will be negligible. These conditions are elucidated in Fig. 3 which also shows how it is possible to obtain a well-defined border of the field by using the beam nozzle with the lead insertion shown in Fig. 2.

The treatment method is similar to the 'moving strips' technique, recommended by PATERSON for so-called trunk-bath radiation. Since with this method conventional roentgen radiation is employed, it is possible to obtain by means of a simple lead cover a homogeneous dose distribution effectively as far as the border of the treatment area and to avoid irradiation of the tissues outside this border.

A depth dose distribution obtained by the different treatment methods for the parasternal metastases described is shown in Diagram 2. The depth dose curves which to a great extent have been calculated from measurements in a tissue equivalent phantom (Mix D, see JONES et coll.) are valid for irradiation in regions consisting of the usual muscle tissues. They are also a satisfactory approximation of the depth dose distribution in the parasternal region in telegamma treatment, where the inverse square law is the major cause for depth dose reduction. In roentgen treatment it is necessary to take into consideration the fact that the radiation dose in the area may deviate considerably from the one indicated in the diagram, due to the actual absorption and secondary radiation conditions. A thorough investigation of the depth dose distribution under relevant conditions as regards the tissues has been inaugurated and the results will be published in due course.

The size of the treatment area is adjusted from case to case depending upon the position of the primary tumour but as a rule it extends from the fourth intercostal space to join with a possible axillary field given with conventional roentgen, or extended to cover the fossa supraclavicularis. Fig. 4 gives information on the placing of the fields, and the beam nozzles selected in three types of cases. As will be seen from these cases, the specially designed treatment tube has been used only for the chain of the parasternal glands; the treatment can possibly be completed with triangular and circular treatment fields with a distance between the source and the skin of 7.5 cm. With these treatment tubes, which facilitate the adjustment in the concave part of the treatment area, an increased depth dose is given in that region where the chain of glands lies deepest.

In example (a) of Fig. 4, the anatomical conditions produce a downward direction of the beams in the fossa supraclavicularis so that a con-

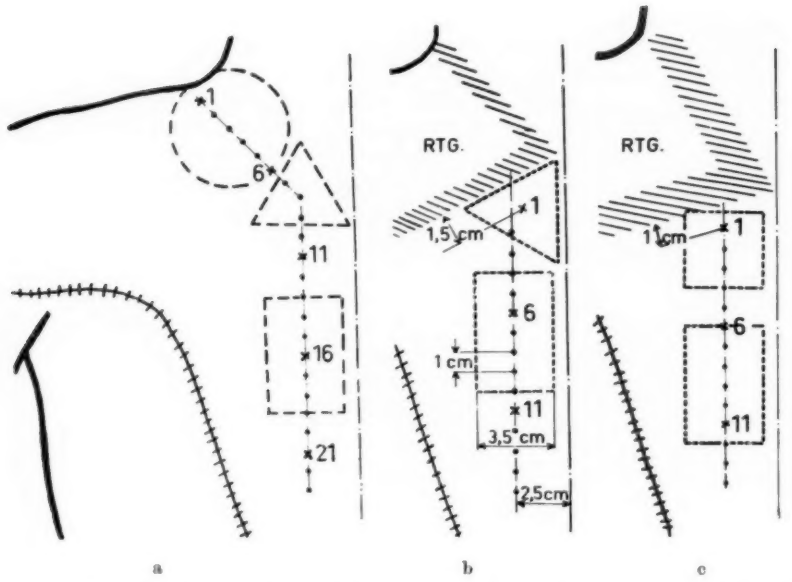

Fig. 4. The placing of the fields and choice of beam nozzles in three cases treated with 'overlapping fields'. Apart from the use of the parasternal tube the treatment selected comprises two types of fields of circular (ø 6 cm) and triangular shape with a SSD of 7.5 cm.

siderable increase of the depth dose effect is obtained by the cross-fire just within this region. The triangular area used in examples (a) and (b) (Fig. 4) has at the skin surface the shape of an equilateral triangle with sides of 5 cm. This has been used to obtain an even radiation dose at the transition of the parasternal and supraclavicular treatment areas. In example (c), the border of the roentgen area is almost perpendicular to the parasternal chain, and the most favourable dose distribution is therefore obtained without applying the triangular field.

The secondary radiation from the roentgen radiation field to the axilla and fossa supraclavicularis produces considerable dose contributions outside the treatment area. Due to this, further irradiation must be applied very carefully on the areas situated nearest to the roentgen irradiated section, or troublesome skin reactions may easily occur. The dose recommended for each field is usually 850 r but must of course be reduced in cases which have received preoperative irradiation treatment. (On account of the moderate irradiation reactions observed, this dose has later on been increased.)

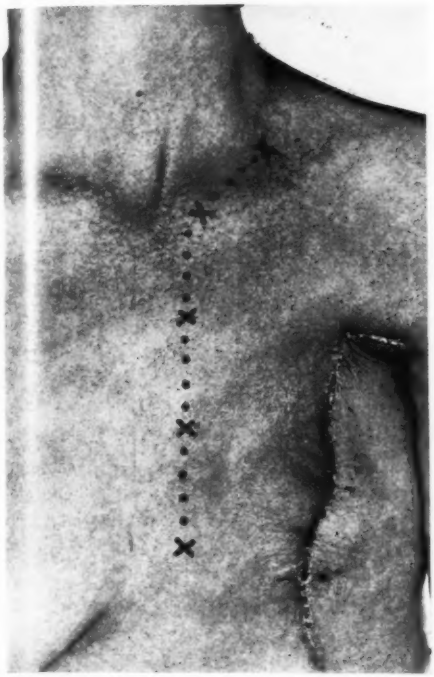

Fig. 5.' Skin marking for 25 fields for irradiation with the 'overlapping fields' technique of the parasternal and fossa supraclavicularis regions.

The treatment fields are localized by skin markings as shown in Fig. 5. Every fifth field is usually marked by a cross to assist identification.

The beam nozzle is provided with a position indicator for the patient similar to that described by BENNER; adjustment is facilitated and the position of the patient during treatment can be checked. The number of fields in a treatment series varies considerably; treatment is usually given daily to one field but in certain cases, for instance when the number of fields exceeds 20, the treatment has comprised two fields a day without any unfavourable reactions. The treatment is not performed continuously according to the field numbers indicated in Fig. 4. In order to prevent that treatment of one and the same tissue area is completed within a very few days there are different schemes for the permutations of field numbers. A series of treatment is usually given within 12 to 20 days. The 74 patients who have been treated according to the principles indicated in Fig. 4, during the period September 1956 —January 1958, are included in group B in the following summary.

Material

Post-operative radiation therapy of the parasternal region by the methods described has been employed at Radiumhemmet since 1955; the indications for its exhibition have to a great extent been controlled by the apparatus available. The material hitherto treated therefore comprises only patients with medially or centrally situated primary tumours and with axillary metastases of periglandular growth; the probability of metastases within the parasternal region in such patients is according to Table 2, more than 50 %.

The time of observation is naturally too short to allow even an

Table 3

Results of roentgenography of the lungs in patients after irradiation

	Not examined	Examined	
		No radiation reaction	Radiation reaction
Group A (Dec. 1955—Sept. 1956)	1	27	10
» B (Sept. 1956—Jan. 1958)	46	25	3
Total	47	52	13

estimate of the results of the treatments. Observations made upon the primary reactions, blood picture, skin reactions, lung reactions, etc of the patients are, however, of a certain interest and are therefore reported below. Considering the differences in depth dose and dose volume received in the methods of Co^{60} treatment, we have divided the material into two groups, A and B, as shown in the tables.

The blood picture is checked during the whole post-operative series of irradiation. The effect upon the blood by the telegamma treatment of the parasternal metastases is difficult to estimate, since most patients had received conventional roentgen irradiation of the axillary and supraclavicular areas immediately before the series. The leucopenia ($\leq$ 2,000 white blood cells/mm^3) which has been observed in a few cases (about 10 %) has been only temporary and trivial so that in no case has it been necessary to stop the treatment series.

Roentgenography of the lungs has been carried out on a considerable number of patients during the period immediately after the irradiation, and the typical reactions of the radiation, which have been observed in some cases, have been found to disappear or decrease. The time of observation has been too short, however, for any conclusions to be made regarding the extent to which radiation fibroses occur and persist. In the material examined roentgenographically there are, according to Table 3, considerably more reactions within group A than within group B; this may be explained by the above-mentioned difference in dose volume within the lung tissues in these groups.

Table 4

Primary skin reactions within the treatment area

	Very little	Dry epidermatitis	Intense redness (no discharge)	Serous dermatitis
Group A	16	16	5	1
» B	16	48	7	3
Total	32	64	12	4

The skin reaction has been carefully observed during the treatment period and the following weeks. As shown in Table 4 it has generally been unimportant or moderate throughout although in some cases a serious dermatitis has occurred. In all cases this has been observed close to the roentgen-treated area over the axilla and fossa supraclavicularis, and emphasizes the care necessary in the selection of the dosage to this area. In some of the cases the reaction caused by the roentgen treatment has been so trifling that the border of the area has been defined only with difficulty, and in these it may be that the parasternal series of treatments has fallen upon the previously roentgen-irradiated area.

The symptoms of the patients during treatment have been uniformly slight. Only 21 (19 %) have complained, most of them of tiredness, and a small number of cough.

SUMMARY

The treatment of parasternal metastases by means of a short distance Co^{60} unit using a special parasternal tube is described. An investigation upon a limited section material to determine the site of the metastases has been undertaken. The adaptation of the 'overlapping fields' technique in postoperative radiation therapy to the supraclavicular and axillary areas is discussed.

ZUSAMMENFASSUNG

Die Behandlung parasternaler Metastasen mit Hilfe einer Kurzdistanz Radiokobalteinheit, bei der man einen spezialkonstruierten parasternalen Tubus benutzt, wird beschrieben. Eine Untersuchung eines begrenzten Teiles des Materiales ist kürzlich vorgenommen worden, um die Lokalisation der Metastasen festzulegen. Die Einfügung der Technik mit sich überdeckenden Feldern in die postoperative Behandlung der supraklavikulären und axillären Gebiete wird diskutiert.

RÉSUMÉ

Les auteurs décrivent le traitement des métastases parasternales au moyen d'un appareil à Co^{60} à courte distance utilisant un tube parasternal spécial. Ils ont fait des recherches, sur un nombre limité d'autopsies, pour déterminer le siège des métastases. Ils étudient l'adaptation de la technique de "chevauchement des champs" au traitement post-opératoire par les radiations des aires sus-claviculaires et axillaires.

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